Vol. XXVI. — No. 5. May 1949.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

SPECIAL ACCOUNTS

summing up the reports on the questions for discussion at the Enlarged Meeting of the Permanent Commission. (Lisbon, 1949.)

SECTION I. — Way and works.

[625 .13, 625 .142 .4 & 625 .17]

QUESTION I.

a) Mechanisation of the maintenance and renewal of the permanent way.

**b) Recent improvements relating to reinforced concrete and prestressed concrete sleepers.
Results obtained.**

c) Recovery and strengthening of metal bridges that have reached the theoretical limit of safety.

SPECIAL REPORT,

by José Chedas BOGARIM,
Ingénieur, Chef de répartition à la Direction Générale des Chemins de fer Portugais.

a) MECHANISATION OF THE MAINTENANCE AND RENEWAL OF THE PERMANENT WAY.

Question I, part *a*) was covered by the two following reports :

Report (Belgium and Colony, Bulgaria, Denmark, Spain, Finland, France and Colonies, Greece, Hungary, Italy, Luxembourg, Norway, Netherlands and Colonies, Poland, Portugal and Colonies, Rumania, Sweden, Switzerland, Czechoslovakia, Turkey, Yugoslavia), by L. MUCHERIE. (See *Bulletin* for January 1949, p. 1.)

Report (America, Great Britain, Dominions, Protectorates and Colonies, China, Egypt and India), by V. A. M. ROBERTSON. (See *Bulletin* for December 1948, p. 728.)

The object of the present report is to

sum up the information received and give the summaries which can be drawn therefrom.

* * *

General.

Mechanisation of the maintenance work has mainly been due to the necessity experienced by the Administrations to reduce costs which are always rising due to the high cost and shortage of labour.

The introduction of machine to do the work at a greater output has made it possible to reduce the number of men in the gangs and increase their sphere of action, thus obtaining a great saving in maintenance costs.

The unfavourable financial situation of the railways in the last few years, due above all to the competition of other methods of transport, which has made it necessary for the different Administrations to make serious economies in their services, has also led to mechanisation to a remarkable extent.

It would appear, however, that the application of mechanical methods is not due solely to its financial advantages.

Technical advantages are also obtained thereby which must not be left out of account.

The work of the staff, for example, is rendered easier and less fatiguing.

The standard of work is higher in many cases and more lasting, which adds to the safety of the track and causes less wear of its component parts.

Some operations are carried out more quickly, which is particularly important when the line is only available for a short period.

In addition, mechanisation makes possible new maintenance methods — grinding the rails, building up defective rail ends by welding, etc. — which improve the running conditions.

Many Railways are carrying out trials of different types of equipment, and new mechanical maintenance methods are being adopted to an increasing extent, even though slowly.

Amongst the countries to which the questionnaire was sent, the United States of America, closely followed by Great Britain and France are those in which mechanisation is the most developed, in fact in the former it may be said to be the general practice.

In the other countries consulted, mechanical equipment is used to a limited extent, and its use is still in the experimental stage.

In view however of the satisfactory results given by the trials in hand, as the replies to the questionnaire show, it is to be expected that mechanisation will become the general practice and will be further developed.

Organisation of labour and work.

The bigger the job, the greater the value of mechanisation, so that its use is completely justified in the case of large scale maintenance and renewal of the permanent way.

But if it is to be effective technically and economically, the labour must be reorganized and a very detailed and thorough study made of the organisation of the work.

Only in this way can the output of the machine be satisfactory.

In the United States, the tendency is to organize large and very specialised gangs, equipped with all the mechanical aids needed to carry out important maintenance or renewal jobs over the longest possible sections, according to a regular working rhythm, which is followed out as far as necessary.

The gangs are subdivided into smaller gangs which carry out a single operation, in order to obtain high output from the men.

Generally local gangs are not mechanised

and their work is limited to inspections and the small repairs which crop up every day.

In Great Britain, no final stage has been reached, but there seems to be a tendency to extend the practice of equipping the local gangs with mechanical aids which enables their work section to be increased without increasing the number of men in the gang.

The gangs are in charge of all the maintenance of the permanent way, whilst other specialist gangs carry out renewals, welding and stabilisation of the level of the bed formation.

In other countries, it is considered advisable to entrust the more important maintenance and renewal jobs to special gangs, who have a large area under their control, whilst the smaller local gangs deal with daily maintenance requirements.

Except in the United States, where the tendency to organize the labour into large gangs is very pronounced, which is not surprising in view of the stage they have reached, generally speaking there are no definite opinions regarding this matter which is still in a stage of evolution.

The organization of the work of the gangs should be the subject of an investigation, carried out very carefully, to make sure that it is effective.

A working programme should be drawn up according to the different operations to be carried out, and the use of the equipment strictly regulated.

The best order for the different operations should be determined, and the speed at which each can be carried out.

Such an investigation is difficult to make since successive operations are involved using equipment of different types working at different speeds, which must form a homogenous whole carrying out the work at a given speed, without which the labour and equipment are badly used.

The protection of the men during work is covered by appropriate measures on the different Railways.

The transport of the labour to the site of work has also received the attention of the different Administrations.

Trolleys, tractors and trains which stop at the site, or lorries for transport by road are used, in order to avoid the time lost by delays in running trolleys on lines with a great deal of traffic. The method of transport used depends upon the size of the gang, position of the work, possibilities available, etc.

In the case of large operations or special work, the gangs can be accommodated in stationary trains.

Choice of type of machine.

It is not possible to formulate a general rule to make a choice from the different types of equipment used for various maintenance and renewal operations.

The choice will depend upon the special circumstances of each Railway.

One of the most important factors from this point of view is the time available for carrying out the different operations in between trains, or by arrangement with the operating department.

On lines with much traffic, the space between two trains is rather short.

The problem of carrying out the work in such a case can be solved in the case of certain operations by the use of light portable equipment.

Such equipment can be fitted with its own motor, either a petrol engine or worked by a compressor or generating set. The generators or compressors can be carried by the men, or mounted on wagons or tractors which can be taken alongside the track, or on special railway vehicles.

The light machines can be used in the intervals between trains and easily removed from the track by 3 or 4 men.

The large machines run on the track used for renewal work, removing the ballast, etc., require fairly long intervals between trains or interruption of the services for some time.

Sometimes these machines are so equipped that they can easily be removed off the track at given points.

The replies received to the questionnaire, show that there is no unanimity regarding the best machine amongst those in use.

On certain railways portable or light types of machine are preferred on account of the greater ease with which they can be brought onto and removed from the permanent way, whilst others prefer larger machines run on the track as these are more economical and more flexible in use.

There is also disagreement regarding the type of motor to be fitted to the machines, and the conditions to be met.

Some railways prefer petrol driven machines, others electricity or compressed air, and each Administration gives the reasons which justify its preference.

In the experimental stage in which such machines are still used in most countries, it is not surprising that there are differences of opinion and different tendencies.

As the working methods and use of the different equipment is perfected, and the economic studies made of their use give some concrete facts on which to estimate their value, the true tendencies will become apparent.

Reduction of costs and labour requirements due to mechanisation.

One of the most interesting aspects of mechanisation is found in the economic results obtained by its application.

Most of the Administrations consulted on this subject have no data making possible any estimation of the saving obtained in maintenance costs due to the use of mechanical equipment.

The details obtained from some railways are insufficient for making a comparative analysis, which would certainly be very interesting.

Only one Railway in the United States gave details about the working capacity of various machines in man-hours.

One of the reports received reproduced an interesting table published by the *American Railway Engineering Association* showing the reduced maintenance costs obtained with a mechanised gang.

All the Administrations are of the opinion that the economic results of mechanisation are appreciable and of considerable value. This explains the general tendency towards mechanisation which is becoming more and more marked on the different Railways.

It is to be hoped that the different Administrations will be able to give the next Congress details of the results obtained by their investigations into the economic advantages obtained by using mechanical equipment and the conditions under which the figures given were obtained, together with all necessary explanatory details.

Maintenance operations carried out on the permanent way by means of mechanical equipment.

The reports received deal with the following operations : —

Drilling coachscrew holes, recutting the seats in the sleepers of flat bottom rails without bed-plates and re-adzing sleepers on double-headed track. — These operations are carried out by means of machines generally equipped with their own motors, and also worked electrically.

Tightening up coachscrews and driving spikes. — Machines with individual motors are used; their use is of value in the case of old track where a great number of coachscrews have to be replaced or re-spiked.

Restoring double headed track to gauge. — This is done in France by a machine combined with a drill and spike driver.

Lifting the track. — In the United States a machine with hydraulic or screw jacks driven by petrol engine is frequently used when the ballast has to be renewed and the track lifted on a large scale. The

machine can be removed from the track by four men. In the same country motor jacks are also used combined with mechanical tampers.

Tamping the ballast. — The machines used to carry out this operation are widely used in several countries.

There are three types : portable machines with individual petrol engines : portable machines driven by a compressor or generating set; and on-rail machines on which the tampers are worked mechanically or electrically.

The use of these machines is being extended both for ordinary maintenance operations and renewal of the ballast.

The portable machines are used with great advantage at points and crossings, where the use of on-rail machines is not possible.

In the United States, machines of this type are used for individual levelling operations, whereas in Europe the tendency is to carry out such operations by the current methods.

The on-rail machines make the work easier for the men. The portable machines are very tiring for the operator when there is a lot of traffic and the machine has to be frequently taken off the line.

Some Administrations are of the opinion that the use of these machines does not appreciably lower maintenance costs compared with hand tamping, but they have the advantage of producing more uniform work, which lasts about 50 % longer than hand work.

Removing and screening ballast. — Various types of machines are used which collect, screen and relay the cleaned ballast and throw out the waste.

In the United States, the cleaning of the ballast between the sleepers is also done mechanically with suitable machines (cribbing machine) with which a second machine is needed to collect and clean the ballast that is collected.

In Europe this work is done by hand.

A considerable saving in labour is obtained when machines are used to clean the ballast.

Consolidating the bed. — In the United States and Great Britain in particular, this is done mechanically and the financial results obtained are of great importance. There is a very great saving in maintenance costs once the bed has been consolidated in this way. The mechanical equipment used varies according to the method of consolidation, which is dictated by circumstances.

Cutting and drilling rails. — These operations are done by hand operated or machine driven equipment.

Building up, hardening and turning rails. — The object of such operations is to prolong the life of worn rails, and good results have been obtained thereby.

In many countries, the ends are built up by various types of welding machines, and the same method has been used on bridges and crossings.

One Administration reports that the life of the rail is increased by 9 % in this way, and another estimates that the increase may be as much as 30 %.

In the United States, the ends of the rails are hardened by heat treatment using special on-track equipment, and this method seems to be one that should be seriously considered in view of its future application.

In the United States and Great Britain, crawler or on-track cranes are used to switch over rails with lateral wear from one side of the track to the other, a practice which according to the information given increases the life of the rail from 10 to 30 %.

Rail grinding. — In the United States, grinding machines are used to rectify the surface of corrugated rails, and shaping stock rails, etc.

These may be operated by petrol or electric engines or by compressors.

Transport of rails. — On most railways ordinary wagons are used, coupled together in the case of long rails.

Other Administrations use different types of wagons with mechanical devices to facilitate loading and unloading the rails, such as winches, cranes, slides, etc.

In Switzerland, low loading trucks of large capacity are used, with equipment for loading and unloading.

* * *

Generally speaking the Administrations are unanimous in affirming the great advantages to be derived from the application of such methods. They are therefore to be recommended and it is hoped that their use will continue to extend.

Renewal of the permanent way.

When the permanent way is renewed all the mechanical equipment provided for the different operations can be widely used.

With work of this kind, it is extremely important in order to obtain efficient output on the section in question to study the organization and stages of work, using for this purpose graphs showing the sequence and progression of the different work to be done.

In the same way as with large scale maintenance work, the gang should be subdivided into smaller gangs, each being in charge of one special job, and forming a homogenous whole, all working at the same speed.

The greatest degree of mechanisation is to be found in the United States, Great Britain and France.

In the first named country, the gangs are highly specialised and this increases their efficiency.

Mechanical plant is used extensively for the following operations :

Mechanical removal and screening of the ballast. — This is done by various types of ballast removers.

Taking up and laying the track. — This is done by well-known types of mechanical equipment or by on-track cranes.

Lifting up and levelling the new track. — Different types of jacks and mechanical tampers are extensively used for this work.

Rolling the ballast. — This is done by certain Administrations before the new track is laid. Rollers are used, or machines which vibrate and ram at the same time.

Renewal methods.

Most Administrations assemble the track on site, and the work is done manually or by mechanical means.

In the United States, the general practice is to take up and re-rail the track on site together with spot-sleepering, using highly specialised gangs equipped with all the tools that may be necessary. The rails are laid by means of cranes and other lifting devices.

In Great Britain and France, track renewals are done with pré-assembled track. The lengths of track are transported to the site loaded onto wagons or lorries.

The new lengths are laid by cranes or other suitable machines.

The old track is taken up in similar lengths which are taken to the dismantling depot.

This method gives considerable savings compared with hand renewal, and has the advantage that a greater amount of work can be done in one possession period.

The use of mechanical appliances is also very interesting in the case of track renewals using long welded rails.

The renewal of track equipment is carried out on the different Railways by means of gantries, cranes or lorries.

* * *

Summaries.

In view of the present stage reached by mechanisation in the different countries consulted, it may be concluded that :

1. In most countries, the use of mechanical equipment is not yet general, and is only in the experimental stage.

2. Important economic advantages can be obtained by the use of such methods for the maintenance and renewal of the track, and these should be increased in the future when more experience is available.

3. In addition to economic advantages, the use of mechanical equipment also results in appreciable technical advantages. The work is often more uniform, better and more lasting, compared with manual work; the time taken for certain operations is shortened, which is of great importance when the line is only available for a short period; the work is less fatiguing for the staff. It is also possible to introduce new maintenance methods, such as grinding the rails, building up the ends of rails and crossings by welding, etc.

4. To obtain a high standard of work and the best output from the equipment, it should only be used by specialist staff.

5. To obtain the best output from the staff and mechanical equipment, it is necessary to make a detailed study of the organization of the work.

6. In view of the experimental and frankly evolutionary stage of the matter in most countries, it is not possible to formulate any definite summaries regarding the type of mechanisation most to be recommended nor the types of machines most suited to the different operations.

7. The generalisation of mechanical methods in the maintenance and renewal of the track is to be recommended in view of the technical and economical advantages made possible by their rational application.

* * *

b) RECENT IMPROVEMENTS RELATING TO REINFORCED CONCRETE AND PRESTRESSED CONCRETE SLEEPERS. RESULTS OBTAINED.

The above question I *b*) was covered by the two following reports :

Report (Belgium and Colony, Bulgaria, Denmark, Spain, Finland, France and Colonies, Greece, Hungary, Italy, Luxembourg, Norway, Netherlands and Colonies, Poland, Portugal and Colonies, Rumania, Sweden, Switzerland, Czechoslovakia, Turkey and Yugoslavia), by M. GONON. (See *Bulletin* for March 1949, p. 153.)

Report (America, Great Britain, Dominions, Protectorates and Colonies, China, Egypt and India), by V. A. M. ROBERTSON. (See *Bulletin* for December 1948, p. 759.)

The object of the present report is to sum up the above reports and present the summaries which can be derived therefrom.

* * *

General.

The use of concrete sleepers on the permanent way dates from the period immediately after the first world war.

The difficulties in obtaining the standard types of sleepers at this period, especially wood sleepers, led certain Railways to introduce concrete sleepers.

In general, satisfactory results were not obtained in practice and very few of the original types tested survived their trials.

The conditions created by the last war once more focused attention on this problem and many applications, based on the experience already acquired, have been carried out in recent years.

Up to the present time, their use has been limited and of an experimental nature, on lines where the traffic is small or not very fast, and on sidings.

The results of these trials have not been altogether satisfactory, and this circumstance, added to the high cost of concrete

sleepers, has limited the extension of their use.

The different types used are still being improved, and it cannot be said that in the present stage of evolution any particular type has given conclusive proof of its superiority.

Even the most perfected types have not been in service long enough for definite conclusions to be formulated concerning them.

However, it is logical to expect, in view of the experimental knowledge already obtained, that in the future the concrete sleeper will be satisfactory and there will be compensations for its use.

For these reasons, various Railways are making a study of the problem, and numerous trials on the line and in the laboratories are being followed with great interest.

The recent use of pre-stressed concrete would seem to give rise to new hopes and possibilities, and it is only natural that all efforts should be concentrated on this type of sleeper.

Extension of the use of concrete sleepers.

Statistical data show that it is above all in France, Great Britain, Italy and Hungary that ordinary reinforced concrete sleepers are being more widely used, but still to a very small extent compared with the wood sleepers. In other countries their use is extremely limited.

Type of sleepers. — The ordinary reinforced concrete sleepers in use can be divided into two main types :

Monoblock sleeper, in the form of a straight beam of approximately constant section.

Combined sleeper, consisting of two blocks connected by one or more tie beams in steel or reinforced concrete.

There are many patterns in each type, which are already well known.

From the replies received from the different Administrations, it may be deduced that the use of the first type is being given up, and that of the second is being extended on account of the greater advantages offered.

The existing types of pre-stressed concrete sleeper are usually monoblock in design, and amongst them mention may be made of the French type, which is flexible and of reduced section in the centre, the type used in Great Britain which is more rigid in this area, and the rigid, hollow or tubular types of great thickness under trial in Italy and Switzerland.

The idea behind the different types is the same, the only difference being due to manufacturing conditions, amount of concrete, arrangement of the reinforcement, etc.

The use of all these types on the line is too recent for final conclusions to be reached on their respective merits.

The types of fastenings used also vary considerably. The fastening of the rail onto the sleepers may be by means of coachscrews screwed into hardwood blocks or metal fittings arranged in the concrete, by means of bolts, coachscrews screwed into metal fittings and rigid or elastic clips.

The bolt-coachscrews can be fitted in the concrete when the sleeper is manufactured.

The rail can be laid on the sleeper either directly or indirectly by means of plates or chairs fastened to the sleeper by the above mentioned devices. Wooden, rubber or felt pads are used to prevent direct contact between the steel and concrete.

The fastening of the rail to concrete sleepers is a delicate point which has greatly interested the technical experts and which will continue to be the subject of many investigations and trials in order to find the most satisfactory solution.

In spite of all the efforts made, no solution has yet been discovered which meets all requirements in practice from the technical and economic points of view.

The elastic type of fastening, recently tested, seems however to have superior qualities to the other methods in use, so that very high hopes are being placed upon it.

Experience to date shows that ordinary reinforced concrete cannot stand up to fast heavy traffic satisfactorily.

Ordinary concrete has insufficient flexibility and elasticity to stand up to the vibrations caused by heavy traffic.

When well designed and carefully manufactured to very strict technical specifications, provided suitable fastenings are used, they will last a long time and prove satisfactory on the lines where there is only a small or average amount of slow traffic, where they have generally been used up to the present.

The monoblock type of ordinary reinforced concrete sleeper will not stand up to the bending stresses in the central portion due to faults in the level of the supports or the effects of the ballast, if these are not quickly remedied.

The combined type is free from these drawbacks and this is why all the Railways tend to adopt this pattern in preference to the other.

It has however the defect that when metal tie beams are used, corrosion will occur, but this can effectively be prevented by encasing the tie and keeping the level of the ballast below it.

The practical and experimental results already obtained with prestressed concrete sleepers would seem to fulfil all the hopes that have been placed on them, even when used on lines with heavy traffic.

Their strength is very great compared with that of ordinary concrete sleepers.

They stand up better to pressure under the rails and in their central portion, and the cracks which tend to form owing to the prestressing effects will close up, and the weight of the reinforcement required is reduced.

On the other hand, the cement used must have exceptional strength and compactness, and the manufacture of this type of sleeper requires very great care and costly equipment.

Specifications for the manufacture of sleepers.

The value of an ordinary reinforced concrete or prestressed concrete sleeper depends not only on its design but also on the quality and use made of the components from which it is manufactured.

Very extensive trials have revealed the heavy stresses to which the sleepers are exposed by heavy rolling loads.

Consequently in most countries their manufacture and acceptance is covered by very strict technical specifications which will be modified as experience indicates is advisable.

In this way, the conditions under which reception laboratory tests are to be made; the maximum loads to be adopted when calculating the strength and stresses allowable; conditions concerning the characteristics required for the reinforcement steel used in ordinary and prestressed concrete sleepers; the composition of the cement and characteristics of the concrete, both ordinary and pre-stressed, the granulometric composition, quantity of water, vibration, setting, etc., etc., are all laid down.

Methods of laying and maintaining track laid with reinforced concrete sleepers.

The great weight of reinforced concrete sleepers leads to great difficulties in laying them.

The loading and unloading of reinforced concrete sleepers is generally done by crane.

The laying of pre-assembled lengths of track is done by means of mobile cranes running on the track or other appropriate machines, similar to those used in the case of line with wood sleepers but suitably modified to deal with the greater weight of concrete sleepers.

Experiments are still in hand to improve the methods used and find other more practical ones.

When renewing the track, it appears advisable to roll the ballast beforehand when reinforced concrete sleepers are used.

This preliminary operation gives a homogenous and regular bed which prevents the excessive wear of the sleepers at the start which so often occurs on newly laid track.

When the track has been renewed, mechanical tamping is to be recommended on account of the compact quality of ballast thereby obtained.

It is best to use ballast not exceeding 40 mm. ($1\,^{9}/_{16}$"), which gives uniform support and facilitates tamping.

It is advisable to leave a furrow down the middle of the track to prevent the centre part of the sleepers bearing upon the ballast.

The level of the ballast should be a little below the tops of reinforced concrete sleepers as they give the track greater stability on account of their great weight compared with wood sleepers.

This not only saves the amount of ballast required, but also saves labour when the ballast has to be removed. It also has the advantage of keeping the metal tie beams of combined sleepers out of the damp.

The level of the track is maintained in the same way as with wood sleepers by all the Railways.

Hand tamping should be done very carefully to avoid breaking the lower edges of the sleepers and thereby exposing the reinforcement.

This drawback does not occur with mechanical tamping.

Packing or measured shovel packing is to be recommended, as regular support is obtained thereby.

Jacks have to be used to align the track owing to its great weight.

The fastenings are tightened up in the same way as with wood sleepers.

Track laid on concrete sleepers is more lasting than is the case with wood sleepers.

Deterioration of concrete sleepers.

Much of the wear observed in reinforced concrete sleepers under loads is due to weakness in the fastenings.

The reinforced concrete sleepers by its very nature has less elasticity to adapt itself to the vibrations set up by heavy, fast loads.

In this case, an unsuitable or badly worn fastening will not give sufficient protection to prevent undue wear of the concrete.

This wear shows itself by cracks and crushing of the concrete under or near the fastenings.

The causes of this wear have been studied on the line and in the laboratory, and certain steps are now possible to diminish them or avoid them completely.

The fastenings must be very tight and the wooden plates replaced in good time. The method of fastening using coachscrews screwed into wooden blocks is not to be recommended, as it is too weak to maintain the correct lateral position of the rail.

If the two blocks under the rails are not level, cracks may occur in the middle of the sleeper.

Arrangements should be made to see that the centre part of sleeper never rests on the ballast.

Other causes of wear in sleepers are : rotting of the blocks into which the coachscrews are screwed and corrosion of the metal tie beams of combined sleepers.

Financial comparison of wood and reinforced concrete sleepers.

M. GONON in his report mentions the difficulties which occur in carrying out a general study of a subject of this kind, where a great many factors come into play, some of which it is extremely hard to estimate, whilst others are directly depen-

dent upon the particular situation arising in each country.

The data supplied by the replies to the questionnaire was insufficient to enable any accurate comparison to be made, which would include all the economic factors governing the use of reinforced concrete sleepers compared with wood sleepers.

Of the study made of standard type of track, the following conclusions emerge :

1° The cost of a concrete sleeper is higher than that of a wood sleeper.

It costs 30 to 50 % more.

2° It costs more to lay track on concrete sleepers than on wood sleepers.

In France, the difference is about 50 % for a line with the same number of sleepers.

3° The use of concrete sleepers will result in maintenance economies compared with wood sleepers on lines with little or average traffic, provided certain abnormal drawbacks in connection with the fastenings are eliminated, as these increase the maintenance required.

4° For the reinforced concrete sleepers to be of interest financially, it must last at least 40 years on the track where it has been used and must not cost more than 50 % more than a wood sleeper.

By the use of ordinary reinforced or pre-stressed concrete sleepers in conjunction with long welded rails, it is hoped that new technical and economic advantages may be obtained in the future in the maintenance and renewal of the track, opening up new fields for the use of concrete sleepers, but only experience will confirm if such hopes are justified.

Strength of the sleepers. — Trials made.

The sleepers are subjected to great strain due to the dynamic effect of the heavy loads running on the track.

It is therefore of special value to ascertain the stresses to which they will be subjected in practice.

To do this, numerous observations and trials have been made to measure such stresses, both on the track and in the laboratory.

This has made it possible to recognise more accurately the causes of the failures which have occurred.

In these trials, the conditions the sleepers have to stand up to in practice have been reproduced as far as possible.

The observations made and results obtained have contributed greatly to the progress made with concrete sleepers as regards the methods of fastening used and the strength of reinforced concrete items.

It appears that several failures which occurred were due to errors caused by under estimating the loads transmitted by the rail on lines with heavy fast traffic.

The experiments made show the real importance of knowing the value of these stresses in calculating sleepers.

Amongst the countries, which have carried out the most important researches in this field, are Great Britain and France.

For example, in Great Britain trials on the line have shown that there is a load of about 25 t. on the chairs when locomotive wheels with a load of 10 t. pass over them.

An investigation has also been carried out to determine the distribution of the pressure under the sleepers, and another to calculate the tension developed in the concrete and reinforcement.

Laboratory tests have shown how different types of sleepers stand up to the action of high static loads with various ballast arrangements.

Trials have also been undertaken to calculate the relative strength of the different types of fastenings used.

The carefully verified results explain the reason for the strict specifications required and the high loads used in carrying out the different reception tests.

Use of reinforced concrete sleepers on lines equipped with track circuits or electrified lines.

Trials carried out in Great Britain and France have proved that the use of reinforced concrete sleepers has drawbacks on lines equipped with the automatic block using track circuits and on electrified lines, as the electric resistance between the rail and the ground is lower than in the case of track laid on wood sleepers.

In these countries, trials are still being carried out in order to find a satisfactory solution to this problem.

Recent improvements made in reinforced concrete sleepers.

Reinforced concrete. — No important modifications have been made to the types of sleepers of this kind in use in recent years, both as regards shape and design.

Pre-stressed concrete. — The good qualities of these sleepers and the hopes to which they have given rise justify the great interest technical experts have shown in them, in order to improve the manufacturing processes and the quality of their constituants.

The need to shorten the time the moulds are occupied, to reduce the time taken for the working cycle and thereby increase the output of the plant, has obliged the makers to study concretes which rapidly attain a high degree of resistance to compression and cutting.

These characteristics have been obtained thanks to a very careful study of the granulometric composition, a suitable choice of the aggregates, and the use of very strong cements with a mix of between 400 and 500 kgr./m^3 (672 and 841 lbs per cubic yard).

The amount of water has been reduced as much as possible, to as little as 6 % of the dry material.

The pouring of the concrete by vibration has been the subject of continual experiments.

The frequency of the vibrations is generally 3 000 per minute, but with the French « Wernberg » sleepers, 10 000 per minute for 4 to 5 minutes has given excellent results.

The use of a discontinuous granulometric composition, investigated by M. VALLETTE, gives the concrete remarkable properties of compactness and resistance to traction and creep.

In this way a strength of 700 kgr./cm^2 (9 956 lbs per sq. inch.) has been obtained within 28 days.

In order to shorten the time the moulds are occupied, certain makers use heat treatment to speed up the setting of the concrete.

In this connection, research work is still being carried out, and it is to be hoped that further progress will be achieved in the near future.

For the reinforcement, wiredrawn steel of 2 to 5 mm. ($^5/_{64}$" to $^{13}/_{64}$") dia. is used, with a high elastic limit of 150 to 180 kgr./mm^2 (95.23 t. or 114.3 t. per sq. inch.) and a breaking strength of as much as 200 kgr./mm^2 (127 t. per sq. inch.)

For reasons of economy special steels with a high elastic limit of between 90 and 110 kgr./mm^2 (57.14 t. and 69.84 t. per sq. inch.) are also used, the diameter varying between 5 and 9 mm. ($^{13}/_{64}$" and $^3/_8$").

The metal is very carefully checked as regards its limit of elasticity, breaking strength and elongation. Preliminary tests are made to avoid breakages when the reinforcement is put under tension, which would disorganize the work.

The prestressed tension of the wires is maintained by simple adhesion using twisted or curled wires, or by means of positive anchorage (welding, buckles, etc.).

Experience has not yet been sufficiently long to prove which of these methods is the best.

The preliminary tension of the wires is very strictly controlled so that the working

rate will closely approximate the elastic limit.

Methods of manufacture.

As prestressed concrete sleepers cost a lot compared with wood sleepers, it is very important that they be manufactured as economically as possible if their use is to be developed.

The strict technical specifications laid down for their manufacture can only be achieved if very modern plant is available with improved equipment, involving a heavy capital investment.

Manufacture on the large bench principle involves the use of large installations which cost a lot and are wasteful of labour and equipment because the working cycle is too prolonged.

The method can be improved if smaller benches are used together with suitable organization of the work, in order to shorten the working cycle.

The method recently adopted by one firm in which the sleepers are mass produced and the cycle shortened by approximately 3 hours is a great improvement.

It is to be hoped that completely mechanical production will lead to a considerable decrease in the cost of such sleepers.

Progress made in the fastenings.

The types of fastenings in use are too rigid to give the concrete sufficient protection.

The use of various types of plates between the rail and the sleepers is not completely satisfactory.

The S.N.C.F. have studied a new type of elastic fastening which appears to give the sleeper and the bolt-coachscrew very good protection against shocks and vibrations.

The method consists of an elastic clip which is tightly fastened up by means of a bolt-coachscrew screwed into a Thiollier fitting and a grooved rubber plate under the rail.

The S.N.C.F. has carried out an interesting series of trials on wood and prestressed concrete sleepers with various types of fastenings, so as to study the behaviour of the whole under the action of strong vibrations.

The results obtained verified that the new elastic fastenings were excellent, as were those using plates with independent fastening of the rail and plate.

These trials also verified the fact that an elastic plate gives good results when it is used in conjunction with a very tightly fastened elastic clip.

To avoid wear of the sleeper, there must be very close solidarity between the sleeper and the rail, so that the fastenings must be kept very tight.

The use of this new type of fastening has given good results in line trials.

Experiments carried out in Great Britain when studying the tearing out resistance of different types of fastenings proved the superiority of coachscrews inserted into holes filled with cement or into blocks composed of asbestos as compared with coachscrews fitted into wooden blocks.

Lines laid on concrete longitudinals.

In Great Britain and France, this method of laying very long welded rails is now being tried out.

Its experimental application is still too recent for anything definite to be known about the way it will stand up in service.

The trials are being continued to find out its stability and what maintenance conditions will be.

In Italy, the method was tested but did not appear to give good results and has been given up.

Summaries.

1. The use of reinforced concrete sleepers is still very limited and merely in the experimental stage.

2. From the experience already acquired it can be concluded that the behaviour of reinforced concrete sleepers on lines with

fast traffic has not been satisfactory. For this reason, their use has been limited to secondary lines where there is little traffic, or to sidings.

3. The combined type of reinforced concrete sleeper, consisting of two blocks connected together by tie beams, has proved to be the better able to stand up to service conditions on such lines.

4. Prestressed concrete sleepers offer greater resistance to impact stresses than the standard types of reinforced concrete sleeper. From the results obtained during the trials already carried out and now in hand, it can be expected that they will give good results on lines with heavy, fast traffic, especially if they are fitted with the up-to-date type of elastic fastening.

The present tendency of research work is to endeavour to improve still further these types of sleeper, which appear to justify the high hopes placed upon them.

5. The use of the ordinary type of reinforced concrete sleeper on lines equipped with track circuits or electrified lines gives rise to serious difficulties on account of their insufficient resistivity.

It is possible that the investigations now being carried out will find a satisfactory solution to this problem in the near future.

6. The method of fastening the rail to the sleeper is very important as far as the protection of the latter is concerned.

The types of fastening which have proved the most satisfactory are :

— indirect fastening, with separate fastening of the rail and the bearing plate, without any intermediate elastic plate;

— a completely elastic fastening (grooved rubber plate and elastic clip) with bolt-coachsvrew screwed into a Thollier fitting.

7. If the use of reinforced concrete sleepers is to prove economical compared with that of wood sleepers, their manufacturing costs must be greatly reduced from the present level, which can only be done by mechanisation of the manufacturing processes.

8. It would be of interest to carry out tests regarding the use of long welded rails in conjunction with that of reinforced concrete sleepers in order to determine the technical possibilities of this method and its financial repercussions.

* * *

c) RECOVERY AND STRENGTHENING OF METAL BRIDGES THAT HAVE REACHED THE THEORETICAL LIMIT OF SAFETY.

This question was covered by the two following reports :

Report (Belgium and Colony, Bulgaria, Denmark, Spain, Finland, France and Colonies, Greece, Hungary, Italy, Luxembourg, Norway, Netherlands and Colonies, Poland, Portugal and Colonies, Rumania, Sweden, Switzerland, Czechoslovakia, Turkey, Yugoslavia), by M. CASSÉ. (See *Bulletin* for February 1949, p. 85.)

Report (America, Great Britain, Dominions, Protectorates and Colonies, China, Egypt and India), by V. A. M. ROBERTSON. (See *Bulletin* for December 1948, p. 782.)

We give below an analysis of these reports together with the summaries.

* * *

General.

All countries base the construction of their bridges on regulations concerning the calculations to be made, loads to be allowed and limits for the stresses due to the passage of such loads.

When built bridges have a large margin of safety compared with the rolling loads expected on the line, and for a certain time their strength is sufficient to meet the increasing weight of the trains necessitated by operating requirements.

After a time, however the excessive increase in the load becomes such that it becomes necessary to check the strength of the bridge to find out if its reserves are sufficient or not.

If so, the bridge has either to be replaced or must be suitably strengthened.

In general, all Railways follow special regulations concerning the limit of safety of bridges under such conditions, set out the loads to be used in checking stability, how this is to be done, the limiting stresses to be adhered to, etc.

In certain regulations, the typical train for new bridges is used, whilst others relate this to a depreciation co-efficient according to the class of line, and others again consider the actual loads which the bridge in question will have to carry.

The limiting stress to be taken into account is usually a little higher than that laid down for new bridges (1 to 2 kgr./mm^2 = 0.634 to 1.269 t. per sq. inch.), but in certain regulations depends upon the limit of elasticity or breaking strength of the metal of the superstructure.

In several countries, the tension of different parts of the bridge under test is measured by strain gauges at the same time as the analytical calculations are made.

Such equipment must be very carefully used and great care taken in the interpretation of the results obtained if they are not to be given an excessive value.

When there is a great divergence between the results of the two processes, the measurements must be continued until the cause is ascertained and a satisfactory result obtained.

Several Railways think the stresses shown by the strain gauges are the correct ones, whilst others only consider those given by the calculations, using the measure of the stresses as a check.

Generally speaking, the stresses shown by measurement are lower than those obtained by calculation.

The stresses adopted must be increased by the impact coefficient, which is generally taken as being equal to that of new bridges.

Certain countries have made trials in connection with their direct calculations, by measuring the moving loads at the most unfavourable speed, to determine with greater precision the real stress on the different parts of the bridge.

As for exceptional loads, certain regulations permit the allowable stresses to be increased when the train speed is reduced.

It may be said that the increase in the rolling loads is the principal reason why bridges have to be replaced or strengthened, but there are other reasons, very small in themselves, which start the trouble.

For example the fracture of an important part, age, alteration of the metal owing to corrosion or other varying factors, according to the opinion of the different Railways.

* * *

When a bridge reaches its theoretical limit of safety, it must be made capable of supporting the loads which normally run over it. Three methods are possible :

1. Replacement by a new bridge;
2. Replacement by a recovered bridge;
3. Strengthening on site.

We are not concerned with the first alternative.

Replacement in the second case is done by using a bridge taken from another line which has been declassified or affected by a renewal programme which has made available certain bridges sufficiently strong to be used on lines with considerable traffic.

If the span is similar, replacement is an easy matter, and all that is necessary is to take up the bridge, transport it to the new site and put it in position after making the small repairs, improvements or slight modifications required in the abutments or piers.

Such a case rarely occurs however, and in most cases the bridge to be used needs to be adapted in the shops, which increases the cost of the operation to such an extent that it may not be economical compared with replacement by a new bridge.

In exceptional cases, large bridges can be used in this way. But generally only average and small girder bridges can be re-used economically, and for this reason several Railways have taken advantage of replacements to make use of recovered superstructures.

No important transport problems arise in their use and they can easily be adapted to the required span.

In practice circumstances are so different in each particular case that a special investigation is required to ascertain the economic results.

The technical aspect of the subject must also be considered, as if a recovered bridge has any defects or weakness in certain parts and is not much stronger than the bridge it is to replace, the cost involved will not be worth while.

Strengthening bridges.

A bridge can be strengthened by the addition of new strengthening parts, rivetted or welded, by altering the part played by the framework, or by increasing the section, by encasing of concrete or reinforced concrete.

Strengthening by rivetting.

If the section of individual members has to be increased, this is done by making additions or replacing them by others. The new parts are rivetted to the old.

The strengthening can be carried out in the shops when the nature or the size of the job warrants it.

In the first case, the work is done without interrupting the train services, though precautions are taken; in the latter the bridge has to be taken to the shops and in the meantime a temporary bridge erected to keep the line open to traffic.

All these operations, transport, taking up and laying the bridge, increase the cost of the work.

The removal of parts which affect the strength of a bridge is done between trains by using auxiliary parts to protect them from the action of the load.

When making reinforcements by this method, special care has to be taken in removing the rivets and in rivetting so as not to cause cracks or deformations in the parts.

The parts are temporarily joined together by bolts or clips.

If special precautions are not taken, the new part will not carry any of the dead weight of the bridge, and the new metal will only be moderately stressed, whereas the old metal will still be excessively stressed.

Various methods have been used to avoid or lessen this drawback, such as partially freeing the structure from the deadweight, the use of an auxiliary beam which can be put under tension, etc.

The distribution of the load between the two parts can be arranged by taking into account their respective deformation, and the coefficients of elasticity of the metal.

Reinforcement by rivetting is the method most widely used, but it has serious drawbacks which makes its use uneconomical and without any appreciable technical advantages as far as the future is concerned.

Furthermore, while the work is being carried out, the traffic may be seriously upset.

Very old bridges or those with great constructional defects need so much new metal, that the small additional strength obtained does not compensate for the cost.

Consequently it is always advisable to make a comparative study including replacement so as to determine the best thing to do.

Reinforcement by welding.

The use of welding to reinforce a bridge makes it possible to attach new parts more easily than if rivetting is used.

The quantity of metal needed is smaller, the trouble of removing the rivets is done away with, and the drawback of having

to take down and the scaffolding involved, which is so upsetting for the traffic, is done away with.

The use of welding is also advantageous in repairing corroded or worn parts, savings being due to unrivetting.

Reinforcements are sometimes designed on the same lines whether carried out by welding or rivetting.

One of the chief drawbacks to welding, and the reason why it has not been used more extensively, is the difficulty of ascertaining the quality of the welds.

Experience shows that if suitable steps are taken, based on practical experience, good quality welds can be obtained which are likely to be successful.

The main accidents occurring to bridges strengthened by welding are generally due to stresses developing in the metal, often the result of a defective welding process.

Consequently when a bridge is to be strengthened, the method to be applied must be carefully studied, the parts carefully designed, preliminary tests of the welds made, and generally speaking all the regulations and precautions prescribed by experience carefully followed.

Particularly attention must be paid to the internal stresses, especially if the metal in question is old iron. In such a case the weld must be very carefully made so that the lamina are not broken up.

To avoid internal stresses, a mixed type of reinforcement is often carried out, welding one end of the addition and rivetting the other, and this has given good results.

To sum up, in strengthening bridges welding is a process which offers valuable economic and technical advantages provided certain precautions are taken and the matter is carefully studied to avoid trouble.

Strengthening by means of concrete or reinforced concrete.

When bridges are strengthened by this means, parts of insufficient strength or else the whole bridge are encased in concrete.

This method has been used successfully by several Railways.

Old trellis girder or arch bridges, made of iron or cast iron have been encased satisfactorily.

In addition to increasing the strength of the bridge, economic advantages are often obtained owing to reduced maintenance costs.

When this method is used, precautions must be taken as regards the quality of the concrete and the way it is used, its adhesion, and the way cracks are to be prevented, etc.

Strengthening metal bridges by altering the part played by the framework.

When a bridge is strengthened in this way, additional parts are added so as to reduce the stresses in the bridge components.

One of the simplest methods is to reduce the span by making a new pier or an arch between the piers which will support the bridge by means of piles.

Another method is to use new girders alongside those of the bridge being strengthened, and connect them together so that part of the load is transferred.

Arches have also been built over or under the main girders of the bridge requiring strengthening. The two frameworks are connected together by means of supports or uprights the tension of which is regulated before they are rivetted so as to transmit part of the deadweight of the bridge to the arch.

The impulse of the arch is absorbed by the web of the girder to which it is connected.

The advantage of this method is that it can be carried out without much upset to the traffic, and increases the strength much more certainly than increasing the section will.

The use of high tensile steel with this method appears to be of interest, as the new metal is not subjected to the stresses in the old metal of the bridge.

In several countries bridges strengthened by the methods mentioned above have stood up very well in service, thereby proving the effectiveness of the method.

Final considerations.

In reading the reports received and the replies given to the questionnaire sent to the Administrations, it is seen that as a general rule all the Railways consider that it is better to renew a bridge rather than strengthen it once it has reached its theoretical limit of safety.

However, certain Administrations consider that reinforcement is advantageous when the quantity of metal to be used does not exceed a certain proportion of that needed for a new bridge, whilst others only consider it of interest in the case of small spans or limit it to bridges which are not above a certain age.

There are no general rules on which the choice between renewal and strengthening is based.

Each case depends on various circumstances — state and age of the bridge to be strengthened, kind of metal, availability of material, and labour, and their recpective cost, operating interest, time required for the work, etc. — which must all be taken into account in the technical and economical investigation, which should be made before any decision is arrived at.

The same applies to the method of strengthening to be adopted.

Each method has its avantages and drawbacks, which must be all taken into account in order to find the best solution.

The mathematical formulae drawn up to determine the economic limits of replacement or reinforcement do not include all the factors which affect the problem, and for this reason no definite conclusions can be expressed but only indications given to clarify our ideas on the question.

Summaries.

1. The principal reason why metal railway bridges have to be replaced or strengthened is the increase in the rolling loads.

2. The strength of existing metal bridges is determined by theoretical calculations, often checked by direct measurement of the stresses on the bridge in question.

3. Each case of a bridge which has reached its theoretical limit of safety should be examined separately, in its own proper place, in order to determine the best technical and economical solution.

The solution considered the most suitable by the majority of Administrations, and that most often adopted, is the complete renewal of the structure.

4. The use of bridges from other lines, when circumstances lend themselves thereto, is an interesting and economical way of replacing bridges, but this method is usually limited to small and medium sized spans of girder type bridges.

5. The strengthening of sections by rivetting is the method most generally used, but it cannot be recommended when the addition of supplementary parts involves removing the rivets from important fastenings.

6. Strengthening by welding is a practical and economical method, not yet widely used, but the work must be very carefully carried out if confidence is to be placed in the method.

Its use on old iron bridges is not recommended.

7. The strengthening of bridges by adding new framework, building new supports, etc., can be recommended when the main girders have to be reinforced, as it makes it possible to strengthen the bridge without modifying the old structure.

8. Strengthening by means of reinforced concrete has given good results, so it may be stated that this method represents an interesting solution.

SECTION II. — Locomotives and rolling stock.

[621 .335]

QUESTION II.

Electric locomotives for fast trains (75 m.p.h. and over). Discussion of adopted and projected types.

1) Arrangement of the axles.
2) Type of axle drive :
   a) motor suspended from the nose;
   b) flexible transmission.
3) Electric motor characteristics.
4) Braking.

SPECIAL REPORT,

by A. d'ARBELA,

Ingénieur, Chef du Bureau des Études de Locomotives, Chemins de fer de l'État Italien.

The question was dealt with in two reports :

Report (Austria, Belgium and Colony, Bulgaria, Denmark, Czechoslovakia, Finland, France and Colonies, Greece, Hungary, Italy, Luxembourg, Norway, Netherlands and Colonies, Poland, Portugal and Colonies, Spain, Rumania, Sweden, Switzerland, Turkey and Yugoslavia), by Messrs. Dr. E. Meyer and Ch. Sthioul. (See *Bulletin* April 1949, p. 271.)

Report (America, Great Britain, Dominions, Protectorates and Colonies, India, China and Egypt), by Mr. G. A. Dalton. (See *Bulletin* December 1949, p. 800.)

The aim of the present paper is to summarise these reports and give an idea of the tendencies which appear to make themselves manifest from the various information received on the subject of recent production of electric locomotives for high speed trains.

To be precise, this latter task has been fulfilled by the reports handed in by Messrs. Meyer, Sthioul and Dalton and which include a systematic account of the problems raised by the increased speed of trains hauled by locomotives and the respective solutions. The principal characteristics of the locomotives considered are set forth in synoptic tables easy to consult and thus do not necessitate our reproducing them in the present report.

The author therefore proposes to add a few general remarks to those of the papers presented and, as far as is possible, to make a comparative examination of the data given in their statements.

General considerations.

The information given shows that only a limited number of railway systems, among those completely or partially elec-

trified, own locomotives that can run at speeds higher than 120 km./h. (74 m.p.h.). These railway systems are : in the U. S. A. the Long Island *, the New York New Haven and Hartford *, and the Pennsylvania *; in Europe: Austria, Belgium, France *, Great Britain, Hungary, Italy, the Netherlands and Switzerland *; in India, the Great Indian Peninsula Railway.

Speeds comprised between 120 and 140 km./h. (74 and 87 m.p.h.) are only reached, for regular trains hauled by locomotives, on a certain number of lines belonging to a few of these systems, in particular those marked with an asterisk in the list given above. Although speeds in excess of 140 km./h. are frequently reached in the case of electric motor coaches running in daily services, the limit of 140 km./h. does not appear to have been exceeded by regular trains hauled by electric locomotives. In effect, in the absence of precise details on this subject, it does not appear probable that the speeds of 90 and 100 miles (about 145 and 160 km./h.), mentioned in Mr. DALTON's paper as the maximum safety speeds of certain Pennsylvania locomotives could be adopted for everyday services.

Now, seeing that a number of railways have had locomotives built, which on a trial run have reached speeds of very near 200 km./h. (124 m.p.h.), or which were planned to even reach 220 km./h. (136 m.p.h.) such as the German locomotive E 19, but who were satisfied with very much more modest speeds on regular services, we must conclude that the reason does not lie in unsurmountable difficulties as regards the construction of appropriate locomotives, but rather in the economic aspects of the question.

In this respect, we should remember that the increase of speed above a certain limit becomes more and more onerous, either as regards that part of the expenses which is independent of the volume of traffic or that which does depend upon it. This arises from several causes : 1) high speeds entail the outlay of important additional amounts of capital that are tied up for track installations, signalling, the supply of power and locomotives that are ever more perfected, more powerful and require more maintenance when the speed is greater; 2) the running of very fast trains on lines that are also used for slower trains causes a reduction of the commercial speed of the latter, owing to frequent overtaking. The result is that the advantage to passengers of high speed trains is obtained at the expense of passengers of ordinary trains, who are much more numerous; 3) the use of rolling stock, in appearance more intense, is not always so in reality owing to the more frequent and lengthy stops, rendered necessary by a more extensive maintenance and by the fact that wear and tear of most of the parts directly concerned in locomotion (types, axle boxes, collectors, etc.) depends to a greater extent upon the distance travelled rather than the time elapsed between two successive maintenance operations; 4) again, a more intensive use of personnel is counterbalanced by the difficulties and expenses entailed by a more difficult selection and a more lengthy and thorough schooling.

From a purely technical standpoint, a speed of 120 km./h. need not be considered as representing a critical value. All problems of locomotion on rails exist and gradually become more difficult to solve as and when the speed increases. These problems can be classified according as to whether one considers the track and the contact line from the standpoint of their relation as to vehicles, and in particular as to locomotives, or else the care of vehicles as regards their surroundings (air-resistance and its influence on current-collectors), or else the comportment of a locomotive to the carriages it hauls (requisite power for traction and braking), or finally the actual requirements for the construction of a locomotive as compared to the running speed.

None of the problems mentioned above appear to be impossible to solve from an absolute standpoint, at any rate for speeds

running up to about 200 km./h., which are the highest achieved experimentally hitherto. But the field of application which is technically possible for such speeds narrows considerably as they increase, owing to three principal limitations: 1) an increase of the minimum radius of curves encountered, related to the speed by a formula of the nature of $r = a\sqrt{v}$ (r radius of curve, a constant, v speed); 2) an increase of the stopping distance, necessitating a greater and greater distance between the points to be protected and those where the signals must be seen by drivers; 3) a lessening of the ratio between the weight hauled and the tractive power required.

From fig. 1 we can deduce, approximately the extent of these restrictions. (The values shown by the curves are only indicative.) The curves R, S and P represent respectively the minimum radius of curves in metres, the minimum stopping distance in metres, in the hypothesis of an almost complete use of adhesion, and the maximum weight in tons which it is possible to haul on the level for each kilowatt of power provided, presuming that this power is developed at the maximum speed and presuming, for the locomotive, a weight of 25 kgr. per kilowatt.

The curves show that the most severe restriction is represented by the stopping distance, connected with the use of steel tyres. It is not impossible that the use of other materials than steel for the tyres of vehicles might improve matters from this standpoint. But there is reason to fear, however, that other parameters such as the tractive effort required will alter from such use, but in an unsatisfactory manner, re-establishing for other reasons the same limit-values of speed.

Arrangement of the axles.

A comparative examination of the data contained in the papers presented shows a very striking difference of conception between American and European constructions.

On the one hand, we find total weights per unit of continuous power which in only one instance (the 2'D2', type R, locomotive of the Pennsylvania Railroad) fall below 40 kgr./H.P., whereas in all the other instances enumerated in Mr. DALTON's report they exceed 45 kgr./H.P. On the other hand, in Europe we find locomotives which, in only one instance, exceed 40 kgr./H.P. (locomotive (4) of the MEYER-STHIOUL report), as compared to the 20-22 kgr./H.P. of several others.

The only comparatively light American locomotive, of which there is moreover only one type and one unit in service, appears to represent rather an experimental construction than the expression of a tendency, seeing that since 1934 this construction has not been repeated. One therefore has an impression that the conditions that exist in North America are not those which oblige constructors to seek an extensive lightening.

That probably arises, on the one hand, from the necessity of there being available sufficient adhesive weight to be able to exert on the rim the very great efforts made possible by the use of a system of automatic coupling and, on the other hand, a widespread use of moulded steel in the construction of main frames.

That implies, moreover, the possibility of using rolling stock having a very great weight per axle and per unit of length, a possibility that does not exist as a rule on European railway systems. Even as regards the latter, the same importance has not been paid everywhere to a very extensive reduction of weight. Just as in the attaining of high speeds, a light construction enforces additional expense, due to a more complex conception and construction and, consequently, more expensive. It must be remembered, moreover, that for a few of the more recent types certain Railways have been obliged to consider the use of a series of ratios of reducing-gears, which makes possible the use of locomotives of the same fundamental type in ranges of varying speeds and on lines having dissimilar cha-

racteristics, but which enforce the adoption of a higher adhesive weight.

Reasons of an economic and operational nature thus concur in explaining the

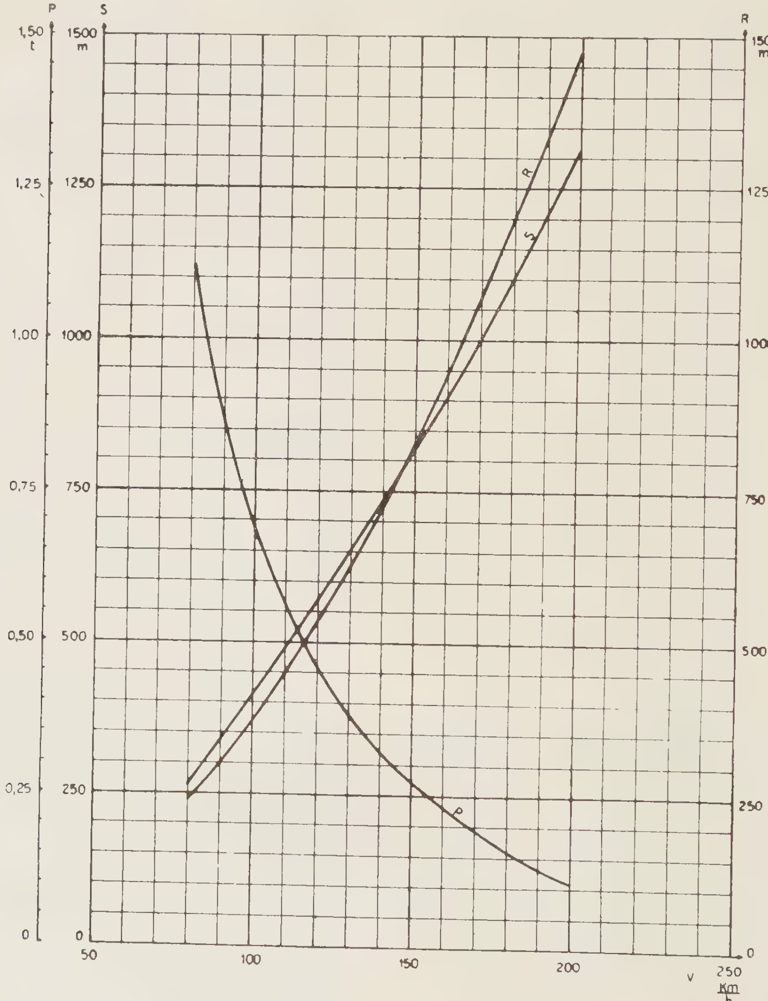


Fig. 1.

apparent dispersion presented by figures expressing the total weight per unit of power.

As regards the arrangement of the axles, it would appear that in America constructors have, since a few years past, reached a stabilisation stage of basic ideas as to the conception of the mechanical part of these locomotives [1], as it appears that it is the disposition of the 2'C-C2' type that has been adopted as a standard by railroads in the U.S.A.

[1] Other criterions appear to prevail as regards the construction of Diesel electric locomotives.

The same does not apply to Europe. As appears very clearly from Table 1 of the MEYER-STHIOUL paper, the interval extending from 1926 up to the present day can be divided into three periods which partially overlap. The first, running to about 1934, shows a preponderating use of the arrangement of axles of the type at present used in America, comprising two leading bogies of two axles. The second period is marked by the adoption of a single axle; the last is characterized by the gradual use of total adhesion locomotives equipped with motor-bogies having two or three axles.

There is no doubt that total adhesion locomotives appear to have very conducive advantages as compared to those fitted with bogies or guiding axles, once the possibility of running them at higher speeds is admitted. This possibility has been demonstrated, for speeds ranging up to 140 km./h., by actual performances, whereas it remains to be proved at higher speeds. It should be pointed out, however, that the limit established for locomotives of this type and built hitherto depends as a rule on the number of revolutions of the motors at maximum speeds; it is therefore fixed in function of the ratio of reduction of the gearing and not as a consequence of running irregularities, as the running remains constant up to the highest speeds allowed.

Total adhesion locomotives having an axle arrangement similar to that mentioned above have been running for a long while, but none of these locomotives have running qualities sufficient for speeds considered in this report.

What characterises the new construction is the presence of a bogie bolster or equivalent contrivances (see, for instance, locomotive 21 of the MEYER-STHIOUL report) which, while exerting a certain compensating effort, allow considerable radial displacements between the body and the bogies.

In this particularity of the construction, which is perfectly analogous to that adopted for a long while past for bogie-carriages, there lies the possibility of running at high speeds, as it is thanks to it that the movement of the body becomes comparatively independent of the alternative radial movement of the bogies and that a too pronounced nosing can be avoided.

In addition, on curves the decided centripetal accelerating forces, caused by pressure on the outer rail and which are necessary to modify the direction of the movement of the locomotive, can be applied gradually and distributed to the various axles owing to their weight, which makes a very distinct difference as compared to locomotives having guiding axles or not provided with bogie bolsters, which have a tendency to negotiate curves by successive jerks or at any rate to concentrate on one or two axles the radial effort required for the negotiating of curves.

Another advantage, arising from the adoption of bogie bolsters, lies in the possibility, which is not to be excluded from other methods of construction, of resting a great part of the weight of the locomotive (body and electrical equipment) of some 40 % of the total weight on supports having much greater flexibility than what would be permissible for the kinematic connections existing between motor-axles and the motors, if the latter were integral with the chassis supporting the body. This circumstance contributes largely to smooth running of these locomotives, although it sometimes entails the use of hydraulic shock-absorbing devices for the purpose of rapidly restricting the extent of the oscillations which occur.

Type of axle drive.

With the exception of a single type of locomotive, of ancient construction (1910), running on the Long Island and on the Pennsylvania railroads, in which the axle drive is done by jack shaft and side-rods (DALTON report), all the other types dealt with in the two reports are fitted with individual axle drive. The superiority of this type of drive is henceforth admitted, even if it entails the necessity of abandon-

ing a certain solidarity between the motor-axles which would be an efficient means of suppressing the undesirable consequences of changes in the weight of the axles due to the tractive effort imparted to the draw bar hook.

Although a connecting-rod drive does not present any difficulties as regards balancing of revolving excentric masses, it often gives rise to very accentuated vibration at certain critical speeds. These vibrations originate in the system of masses and flexible parts consisting of the motor armatures, the rods connecting them to the axles and those connecting the axles to each other. The difficulty of foretelling with exactitude these unpleasant and sometimes dangerous anomalies has helped to lead constructors to an exclusive use of individual axle drive, whilst making use of the progress achieved in metallurgy and in mechanics, in the quality of makes of steel and in precision in gear-cutting.

Rotary movement transmitted by means of gears comprises a constant parallelism and a constant distance between the axles of the toothed wheels engaged. We could thus divide the driving device into three elements : the motor-axle, the couple of toothed wheels, the motor shaft, to which could be imparted (within given limits) : 1) full liberty of reciprocal movement, for the purpose of allowing buckling between the axis of the axle and the axis of the toothed wheels and between the latter and the axis of the motor, or else : 2) liberty of movement restricted to only two of these elements : *a*) axle-couple of toothed wheels; *b*) couple of toothed wheels-axle of the motor, or else finally : 3) complete solidarity between all these elements, viz. a constant parallelism between the axis of the axle and the axis of the motor. This latter case entails a certain degree of liberty of the supporting organs of the motor on the chassis which carries it.

The possibilities of reciprocal movement, which we have enumerated, are obtained by means of articulations or deformable organs interposed between the elements comprising the driving device.

The condition enumerated under 1) is exaggerated to obtain a correct kinematism and as it would entail unnecessary complications it has not been adopted by any constructor, For condition 2), *a*), there are the solutions according to which the rim of the toothed wheel is mounted on a more or less extensive hollow axle, connected by flexible organs or articulations to the axle or else to the wheels; for condition 2) *b*), there are the solutions in which the crown is fixed on the axle, and it is the pinion which is connected by means of flexible organs or articulations to the motor shaft.

The third condition enumerated corresponds, finally, to the solution called « motor suspended from the nose ».

The multiplicity and variety of solutions adopted in locomotives dealt with in this report, among which there even appears suspension from the nose, of which the origin dates back to the introduction of electric traction, all point to the fact that the opinions of specialists in this branch are very divided.

No doubt locomotion imposes on the track, as on locomotives, stresses that increase with speed and with the amount of unsuspended weight. Among the driving systems adopted, some of them preserve both the track and motors from any reactions due to the inertia of their mass under the effect of sudden accelerations of the whole or rotary accelerations of the armatures. Others attain their object in a much less complete manner, but have such advantages as regards simplicity that in a few instances there has been no hesitation in applying them.

Faced with such a state of affairs, it is impossible to form a definite opinion on a subject which still appears to be in a state of evolution. It is to be hoped that systematic and rigorous observations, which are moreover very rare, carried out in cases where it is possible, will lead to the discussion of data drawn direct from experience, the only kind that can settle questions of this nature.

Electric motor characteristics.

The maximum speed of a locomotive is connected with that of the motors by the ratio of reduction-gearing adopted. The attaining of high speeds therefore raises no particular problems, as regards the speed of the motors, but rather as regards their power. It is therefore in particular a matter of space taken up, weight and an appropriate selection of the system of drive for the axles and the ratio of transmission, rather than problems concerning the actual construction of the motors. The diversity of the feed systems raises, moreover, questions that are particular to each system. The general fact to be remembered, at any rate as regards part of the European systems, is a fairly widespread tendency to ultra lightening. However, here again it is a matter of a rule subject to many exceptions, for it is not generalized.. For electric machines, as in mechanics in general, lightening carried beyond certain limits represents additional expense and risks which do not always find sufficient compensation in corresponding running advantages. Light machines are particularly sensitive to intense overloads and of short duration or to eventual interruptions of ventilation because, in most instances, it is a question of motors that require very considerable quantities of air when running at their full speed.

In this connection, it would be very useful if to the indication of the unit-hour or continuous power of the motors there were always added that of the intensity of the corresponding ventilation because the figure indicating the weight per unit of power alone does not give a complete idea of the kind of construction with which one is dealing. In effect, we are faced with values that diverge a lot from this figure, running from 3.2 to 13.1 kgr./H.P. (continuous power) for a monophase current (the latter figure refers to an American construction of 1934-35), from 3.8 to 8.8 for a 1 350-1 500 V direct current, from 9 to 9.8 for a 3 000 V direct current and 2.6 kgr./H.P. for the three phase motors of the Hungarian monophase locomotives, still being built at the present moment.

Owing to the lack of certain data, one is somewhat at a loss to deduce precise indications. A thorough examination of this question would be very useful to discover the possibilities of developing the motors of the various systems.

Braking.

As we have already pointed out, the problem of braking at very high speeds represents one of the three principal technical limitations to practical attainment of such speeds. But it is a problem that is in no wise restricted to appliances installed on locomotives. A complete review of the question should comprise a number of data concerning hauled vehicles, which goes beyond the scope of these reports. As regards locomotives for fast trains, it is evident that the reduction of stopping places to the smallest number possible means the best use of the weight of the train, locomotive included. It is consequently not surprising to find that in a few instances recourse has been had to fairly complicated devices to ensure such use.

We see a tendency to use multiple shoes with a view to a more uniform dispersal of the pressure between shoes and tyres — which tends to alter, due to thermic deformations of the shoes — and to lessen the specific pressure, as well as the fitting of automatic appliances for regulating pressure in the cylinders, in order to keep pace as nearly as possible with the variation of the coefficient of adhesion.

But the greatest difficulties lie in the enormous powers required for great slackening of speed and of which the dissipation creates new problems, as it imposes on the tyres thermic constraints that cannot be ignored.

Just like purely mechanical solutions, electric systems encounter great difficulties. If, for braking, one uses the traction motors the obtaining of decided torques requires intense currents which create great switch

difficulties at high speeds. One can therefore only take into consideration this means as an addition to ordinary braking.

Summaries.

1. Concrete achievements show that the construction of locomotives for speeds running up to 160-180 km./h. (100-112 m.p.h.) is possible. The principal and most severe technical restrictions to the adoption, for normal services, of speeds of this kind arise from the layout of the lines and signalling requirements, in conjunction with the minimum number of stops.

2. The evolution of the mechanical part of locomotives is subject to the influence of predominant conditions on the various Railway systems, which explains certain important differences found between construction in the U. S. A. and in Europe, the former tending towards an arrangement of axles comprising two axle guiding bogies and articulated frames, whereas the latter appear to tend more to locomotives with a total adhesion weight, fitted with motor-bogies having two or three axles.

3. The numerous systems of axle-drive in use appear to be still in a state of evolution, although constructors appear to prefer solutions allowing a certain liberty of movement between the ensemble of the toothed wheels in mesh and the axle or else the motor-shaft.

However, the system called « motor suspended from the nose » does not appear to have been entirely abandoned and is perhaps still capable of improvements which will attenuate its defects.

4. There is no particularity as regards the traction motors used on fast locomotives.

5. The problem of braking still exists in spite of progress made for a better use of adhesion and friction and appears as the most difficult to solve in view of the great power to be dissipated.

SECTION III. — Working.

[656 .225 & 656 .261]

QUESTION III.

Transport of miscellaneous goods.

Concentration in a certain number of selected centres (stations) of miscellaneous traffic, transport by rail between centre-stations, by road or rail between the originating point and the nearest centre-station, and also to the last centre-station near the destination.

Interest of the scheme for the conveyance of goods traffic.

Organisation of the station-centres and of the collection and delivery services.

Financial results of the scheme.

SPECIAL REPORT,

by Dr. J. Faria LAPA,

Chef de la Division Commerciale de la Compagnie des Chemins de fer portugais.

The question was dealt with in two reports :

Report (Austria, Belgium and Colony, Bulgaria, Denmark, Spain, Finland, France and Colonies, Greece, Hungary, Italy, Luxembourg, Norway, Netherlands and Colonies, Poland, Portugal and Colonies, Rumania, Sweden, Switzerland, Czechoslovakia, Turkey and Yugoslavia), by G. MOULART. (See *Bulletin* for April 1949, p. 229.)

Report (America, Great Britain, Dominions, Protectorates and Colonies, Burma, China, Egypt, India and Pakistan), by P. H. SARMA. (See *Bulletin* for March 1949, p. 209.)

The present report sums up these two reports and presents the summaries which can be drawn therefrom.

I. INTRODUCTION.

With rare exceptions, which are easily explained, all the railways in world for some years have been passing through a difficult phase from which it is imperative to build up a healthy financial situation, based essentially on the effectiveness of the services.

The possibility of increasing the rates — apart from those changes due to adjustments in values owing to variations in the purchasing power of the currency — becomes more and more difficult, either because what is known to the economists as the « transport resistance » has reached the maximum compatible with the normal traffic for passengers and goods, or because, failing a rational co-ordination of overland transport, it cannot fail to be seen that an increase in the rates could lead to the opposite results, or because the Governments consider an increase incompatible with the political economy of the times, or because the position of the railway is unfavourable when its cost price is compared with that of road transport, because the latter are run under unfair conditions,

economically, fiscally and socially, or because, finally of other reasons particular to each country or each district.

Under these conditions, the Railways, anxious to improve their services, are naturally led to intensify at the same time their investigations into ways of reducing their costs.

In this connection, within the narrow field of operating requirements, the Railways are endeavouring to replace existing sources of power by others which cost less, to improve their equipment, both active and passive, in order to make it more economical, and also, by intelligent rationalisation to obtain from it the maximum productivity, which is essential if the law of diminishing costs is to come into play.

Questions relative to the transport of miscellaneous goods come under this category, but it must be pointed out that this is affected by other circumstances, amongst which mention must be made of the preoccupation of all the Railways to improve the services offered to the public continuously, not only as the logical result of their character as a public service, but also because this is the desire of all commercial undertakings.

Although this transport takes different forms in different countries, it is nonetheless true that it gives rise to similar problems in every case.

In fact, in those countries where road transport is mainly a question of hire — the vehicle is at the disposal of the hirer — rather than of regular services — in which there is no hirer but simply a consignor of one or more consignments — the railway parcels traffic does not suffer as much competition from the road as in countries where the second practice prevails. In the former case, the road services are mainly interested in complete loads, although competition is also felt in the case of parcels traffic on routes where there is a regular volume of traffic.

In countries where the Post Office has a large traffic of small consignments, which should be transported rapidly by rail, the railway parcels traffic feels the competition of these services to a certain extent; competition is less when the Post Office limits the size of parcels accepted and when the railway has a certain liberty in deciding their routing.

On the other hand, everywhere the specific value of the parcels traffic is higher than that of complete wagon loads, and everywhere, naturally, the unit weight per consignment is less than that of complete loads.

The first of these characteristics makes it only reasonable to charge higher rates while the second reinforces this decision for psychological as well as material reasons, since the charge for each package will not amount to much.

Because of the above, it naturally follows that in all countries the parcels traffic plays an important part under the heading « Receipts » and that, moreover, it is everywhere necessary to reduce the cost of transport of the miscellaneous traffic which requires more handling and is also harder to work in with a proper user of the stock — in sum, more costly.

It must be stated however that the conclusions arrived at in any study of this subject cannot be of universal application, neither in space nor time, even it they were complete, very detailed and drawn up with the skill which characterises those which served as a basis for this present report. Innumerable circumstances due to the legal form of the management of the different systems of transport, the direction taken by the political economy, the greater or lesser protection given by the custom duties which reflect upon the cost of the materials required in the operation of a railway, the sources of power available, the cost of labour, as well as the abundance or shortage of labour, the density of the road network and the railway, the amount of traffic and its composition, etc., etc., make the situation in which the railway finds itself very different from one country

to another, and determine the specific solutions aimed at in each case.

Moreover, within each country, certain charges may occur which will alter the principles adhered to as giving the best results to date. It may be remembered for example that in certain countries, during the recent war, many clients were able to send goods normally sent in complete wagon loads by parcels traffic in view of the difficulties experienced in obtaining wagons the use of which was restricted by the Authorities in order to assure preferential treatment for certain essential products, which generally were transported in complete wagon loads. Restrictions of this kind are still in existence on the Indian Railways for miscellaneous goods.

The composition of that portion of the traffic classified as parcels traffic is consequently upset by the introduction of some part of that traffic, which has always been considered as complete wagon loads. The return to normal, although not completely attained, will no doubt correct this deformation in the composition of the two kinds of traffic.

The above considerations do not prevent it from being appreciated that the Railways have the greatest interest in ascertaining the routing and methods considered likely to solve the problem of reducing the cost of the parcels traffic and improving the service by increasing its « usefulness » to the public.

We wish to profit by the occasion and express our thanks to Messrs Moulart and Sarma for the care with which they prepared their reports.

II. INVESTIGATION OF THE QUESTION.

A. Present organisation of the miscellaneous goods traffic.

1. *Obligations and rights of the Railways.*

The legal obligation to accept parcels offered for transport is common to all the Railways — it is the inevitable result of their legal position either as a public utility or public service. The exceptions made in the case of certain goods or consignments (dangerous goods, explosives, etc., and parcels above a given size or weight) do not in any way detract from this principle.

The loading and unloading of consignments, for obvious reasons, falls to the railway — with the exception of certain units exceeding a certain weight limit.

Generally, the cost of transport varies according to the weight and distance, and sometimes also depends on the kind of goods (specific value, part played in the economic life of the country, etc.) and also, in certain cases the specific weight.

Whereas certain Railways still retain the traditional division of goods into two categories — Express and Slow goods — with different rates and transit times, such a distinction is not made on others or has been given up; the number of railways who are giving it up continues to increase, since it is the principal obligation of the railway to transport goods as quickly as possible.

Many railways have organised collection and delivery services, although in some countries these are limited to the large towns.

2. *Obligations and rights of road transport firms.*

The tendency appears to be to submit road transport firms to the same obligations as those applying to the Railways.

In Norway and Sweden, since the 1st January 1948, road transport has been regulated on the same lines as the Railway. In Poland, whilst awaiting the conclusion of an investigation into rail-road co-ordination, a very large part of the road transport services are run by a State organisation. In Great Britain, the working of long distance road traffic under the control of the « British Transport Commission » seems to have assured the correct equilibrium between road and rail.

In many countries, the activities of road

transport firms are submitted to certain limitations regarding either their mileage, or the kind of goods carried, or the loads for the vehicles used, or an obligation to apply the official rates or respect the maximum rates fixed by the Authorities.

On the other hand, in other countries, road transport firms enjoy complete liberty of action.

3. *Importance of the miscellaneous goods traffic compared with local economic conditions.*

In Europe, the number of stations open to parcels traffic varies a great deal from country to country — from 47 to 100 % of the total number of stations; the average daily tonnage lies between 0.7 and 8 tons, and this tonnage represents between 0.02 and 1.2 tons per 1 000 inhabitants.

The number of stations with door to door services also vary considerably; in certain countries such services are practically non-existant, while in others they are working on a very widespread scale. However such stations, especially in Europe, only represent a very small percentage, generally less than 50 %. Although, as far as those countries which supplied details of the population served are concerned, it must be recognised that the proportion of the population benefiting from such services lies between 25 to 80 % of the total population.

It is opportune to stress this great variation in view of the considerable importance it may have when endeavouring to find the most suitable solution for the problem we are now considering, for each particular country.

4. *Importance of the miscellaneous goods traffic compared with the operation of the railway.*

From certain points of view the information available shows that there are considerable differences from one country to another.

The average weight per consignment varies between 35 and 781 kgr. (78 and 1 722 lbs.), but it would appear that a lower average, somewhere around 80 kgr. (176 lbs.) is the more general, which explains to some extent the high unit cost of booking in, classifying and delivering consignments.

On the other hand, the daily number of consignments per kilometre of line varies between 0.6 and 16 on the Continent of Europe.

A comparison of the data supplied concerning the tonnage of the miscellaneous goods and that of complete wagon loads — with the exception of one country alone — shows that as a general rule the amount of miscellaneous goods is 2 to 40 times greater than the number of complete wagon loads.

This disparity justifies the reservations made regarding the general application of any solution.

The miscellaneous goods traffic expressed in tons does not as a rule exceed 7 % of the total traffic; this result is also obtained when the ton-kilometres for the two kinds of traffic are compared, which shows that the average mileage is about the same in each case.

However the smallness of the parcels traffic shown by the above figures is only apparent, because from the point of view of the receipts, the results are very different. In fact in one country where the parcels traffic only amounts to 6 % of the total traffic, the receipts from it total 26 % of the whole, and in another country where the tonnage amounts to 10 % of the total traffic, the parcels traffic accounts for 55 % of the total receipts.

These details are confirmed by the ratio between the two kinds of transport, which lies between a minimum of 2 and a maximum of 11, in favour of the miscellaneous goods traffic.

The dissimilitude of this ratio is not solely due to the fact that the cost price is not taken into account in fixing the rates.

It may happen in certain countries that the determination of the cost prices are still in the rudimentary stage, their accounts being entirely commercial without any industrial concern. Indeed the determination of the cost of railway operations is an extremely complicated problem to which a great deal of literature has been devoted, the solution of which is a mathematical limit which can be aimed at but never finally reached. For the rest, when a certain limit is exceeded in noting and analysing the different stages, essential for a strict classification of the expenditure, the processus becomes so difficult and hasardous that the Railways may well hesitate to embark upon it.

But the extreme differentiation in the unit receipts in each country and from one country to another, has its basis in fact on economic and social considerations. In many countries, it is affected by the character of public utility attributed to the railway, from which results the fact that its operation is not entirely according to economic rules, as the Government instead of the proper accountancy principle — that the rates should total the cost plus a reasonable profit — prefer to apply the principle of economic equilibrium for internal services, varying according to time and place, which may lead to very different rates being charged although the cost price is the same.

For this reason, these Governments will not agree to certain increases in the rates, any more than they will consent to reductions without being certain that such a policy will not have any bad effects on the Railways or the economy of the country in general.

If the rates were based exclusively on the costs, there would be an immediate tendency to make a substantial reduction in the scale of unit rates, or in other words, the Railways would become completely indifferent to the economic and social interests of the country, a failing for which road transport firms are justly blamed in many countries.

Moreover, regarding this question of the unit rates for miscellaneous goods traffic, it must not be forgotten that the bulk of the latter consists of finished goods, consigned by the producers direct to the consumers, or sent from one firm to another — and consequently in the final stage of the traffic cycle — so that consequently they can support higher rates without any excessive repercussions, all the more so as the low average weight of each consignment means that the charge does not amount to much in each case, which is important from the psychological point of view, as has been previously remarked.

Moreover, in most countries, it must not be forgotten that the Railways are obliged to carry certain essential goods (raw materials, basic products, etc.) at very low rates, and the equilibrium of the accounts has to be obtained by charging higher rates for other traffic, whenever the deficit cannot be directly supported by the community in one way or another.

These obligations of the railways and the compensations entailed thereby are against basing co-ordination of railway and road transport on the cost of each method of transport, all the more so as the excellent doctrine and legitimate interest of seeing that the traffic is upset as little as possible by the « transport resistance », means logically that the principle of differential rates which the Railways have to observe should also be extended to road transport firms.

5. *Accepting and delivering parcels, formalities, documents, equipment.*

There is no appreciable difference from one country to another.

6. *Transport of miscellaneous goods traffic.*

The Railways make use of pick-up and distributing wagons, as well as through wagons, as well as separate wagons for collecting and distributing goods where there is much traffic.

Certain countries deal with the wagons in specially equipped station centres, whereas others do all the work in junctions or during the journey.

On certain important routes, the goods are sorted in the trains themselves in Italy, by employees travelling on the trains, corridor wagons being provided for this purpose. This excellent, but naturally costly service, which is somewhat similar to that practised by the Post Office, speeds up the loading and unloading of goods, and to some extent makes transhipment unnecessary.

Systematic routing through station centres, which is done in Austria, Belgium and France, can be summed up as follows :

In principle each pick-up wagon is sent to the station centre or transhipment depot of the area. Here goods are transhipped and loaded onto through wagons to the station centre in the destination area. This station loads the distributing wagons serving the different stations in the area.

In this way, transhipment is limited in theory to twice, but in fact intermediate handling can be still further reduced since nearly every station which can group the minimum tonnage laid down [1] - 1 (Great Britain) to 10 (America) tons, according to the Railway — is allowed to send a through wagon either to the station centre at the end of the journey or to any other station or group of neighbouring stations; the first station centre can also send through wagons to certain destination stations provided the same conditions are adhered to.

The transport of wagons between the station centres usually takes place on fast goods trains : special trains, mixed parcels and complete wagon loads.

The pick-up and distributing wagons go by slow goods train and sometimes by stopping passenger train. In France and Belgium only express consignments and postal packages go by passenger train.

[1] On the Continent of Europe from 3 to 5 tons.

Systematic routing by means of station centres has made it possible in Belgium and France to reduce the number of wagons used for the same amount of traffic by 30 %.

In many countries parcels travel by the ordinary goods trains and by passenger train (wagons and vans).

No Railway makes use of compartment wagon, except Belgium for carrying papers and Greece for international traffic.

The value of the average output of the wagons used for miscellaneous goods seems to be affected by the ratio between the capacity of the wagons and the minimum loads fixed for through wagons, which vary a great deal : from 1 tot 1.5 tons in Great Britain, 3 tons on the metre gauge lines of India, Egypt and Irak; 3 to 5 tons in Belgium and France; 4.5 tons on the wide gauge Indian lines, and 10 tons on the American Railways.

On the European Railways, the average load per wagon varies between 3 and 3.5 tons, except in Italy and Poland where it is 5 tons, whereas on the Pennsylvania Railroad and Long Island Railroad it reaches 7.6 tons.

It can be concluded from these limits and these results that the Railways endeavour to organise their miscellaneous goods traffic according to the circumstances existing in each country, and naturally without losing sight of the fact that, apart from the good utilisation of the stock, other considerations apply, amongst which the speed of the transport and the cost of the way it is organised must be distinguished.

The excellent description of the policy of the Belgian Railways given in the final part of M. MOULART's Report will no doubt be of the greatest interest to those Railways, who are thinking of revising their present methods.

7. *The characteristics of the trains run between transhipment depots.*

Through parcels trains connecting up the transhipment depots are limited on

several Railways to the most important routes, the services on the others being assured by stopping pick-up and collecting trains.

Whereas the through trains consists of 30 to 40 wagons (400 to 500 tons) and run at speeds between 40 and 80 km. (25 to 50 m.p.h.)/h., the stopping trains usually only run at 40 km./h. and only consist of 20 to 30 wagons.

On the British Railways, the daily services link up all the important towns and most of the transhipment centres in the one day. The average mileage of the wagons is 48.8 miles on the Pennsylvania Railroad and Long Island Railroad.

8. *The trains used for pick-up and collecting wagons and through wagons.*

The Railways who have no transhipment centres, send their slow goods parcels traffic by ordinary goods train. The other Railways either make use of the mail trains or the ordinary goods trains.

9. *Selection of the site of transhipment centres.*

Although the majority of the Railways consider that transhipments should be carried out at the important junctions as determined by the configuration of the system, others are of the opinion that the tonnage to be transhipped must also be taken into account, as well as the direction of the traffic currents and the facilities regarding connections and train services, while the French Railways state that they also think it necessary to select sites where the local traffic is of considerable importance. In Great Britain and America, few of the transhipment centres are nothing but transhipment centres.

On certain Railways, the transhipment depots are only linked up with the railway, whilst on others there is also road access. Road access plays an important part in such cases, making it possible to organise such additional services as door to door services by lorry. On the Pennsylvania Railroad and Long Island Railroad, lorries for both loading and unloading have direct access to the wagons on the platform.

10. *The characteristics of transhipment centres.*

There is a definite tendency to mechaise as far as possible all the loading, unloading and transhipment operations; the size of the platforms and the extent of the lines depend in general on the tonnage to be handled and whether this is exclusively transhipment traffic or local traffic as well.

The information supplied by the different Railways especially that received from the British Railways given in full in M. Sarma's Report, will doubtless be of the greatest interest in the solving of the problems before the different Railways.

11. *Organisation of night work at transhipment centres.*

Only in Algeria, Italy, Norway, and Tunisia and on other Railways with very little traffic, are transhipment depots only open by day; on the other Railways they work both day and night. This not only saves a lot of time (in most cases 24 hours) in the transit time, but also in the time taken for delivery service, as is shown by the information supplied by the British Railways, who are able in this way to deliver early in the morning consignments which came in during the night after 10 p.m.

With a few rare exceptions, consignments from the area served by the centre and those from other centres are all dealt with at the same time. It appears advisable to handle them separately however when work is carried on at night.

Consignments are dealt with the same day as they are received in Algeria, Belgium, Spain (express goods), Finland, France, Switzerland and Turkey, and on the following day in Spain (slow goods), Italy, Norway, Sweden and Tunisia.

As a general rule, only centres working both day and night find it possible to include consignments in the distributing trains on the day they arrived; in other cases this can only be done on the following day.

Most of the European Railways, especially those with a large amount of parcels traffic, do not check up consignments against the waybills, since the parcels are sufficiently addressed to make their routing quite clear.

On the Railways of the Continent of Europe, the average daily output of the personnel of the transhipment depot lies between 4 and 6 tons, but France expects to get an output considerably exceeding 6 tons in her large mechanised centres without platforms; in Great Britain the output is 1.68 ton per man-hour.

The average output per man varies considerably from one centre to another, and depends upon the kind of traffic, the number of destinations, and the mechanical equipment available, as well as the regularity of the traffic.

12. *The part played by containers.*

All the Railways recognise the advantage of containers from the point of view of facility of handling, losses and damage; however those Railways possessing them do not make general use of them for traffic which has to be transhipped.

On the British Railways, containers packed with miscellaneous goods are considered as being complete wagon loads.

The containers belonging to the Egyptian Railways are used exclusively for household furniture.

The rates charged vary widely; they are charged either according to the gross weight, or the nett weight; when empty they travel free or are charged on the gross weight.

13. *The transport of express goods and postal packages outside the collection and distribution areas.*

The general practice is to send them by fast goods trains on the main lines and by passenger train on the secondary lines.

14. *The part played by grouping agents.*

Most Railways agree that the work of grouping agents increases the number of through wagons, gives better use of the rolling stock and reduces the handling required.

As a general rule, wagons sent by grouping agents come under the rates for complete wagon loads. In Algeria, Austria, Spain, France and Switzerland additional rebates are granted in favour of recognised grouping agents. The Pennsylvania Railroad and Long Island Railroad consider that it is doubtful whether the reduced rates allowed are made good by a corresponding reduction in the operating costs.

The possibility open to grouping agents to divert remunerative traffic to the road only exists in those countries where road transport is not regulated.

Approved grouping agents have to give a guarantee in return for the reduced rates allowed them and such other facilities as offices on railway premises as they receive in Algeria, Austria, Spain, France and Switzerland; in the latter country the sphere of action of grouping agents is limited to distances up to 15 km. (9 miles).

The tonnage of miscellaneous goods handed over to the railway through grouping agents compared with the total of this traffic is :

In Algeria	5 %
In Denmark . . .	6 %
In Belgium . . .	11.5 %
In Austria	18 %
In France	18 %
In Sweden	18 %

15. *The part played by secondary railways.*

In most countries, the secondary railways carry out transport from one end of the journey to the other. To enable them to do so, they have combined rates in agreement with those of the main line railway.

16. *Organisation of lorry services for the collection and delivery services.*

The policy of the British Railways is to get their clients to leave the cartage services in the hands of the railway so that the flow of goods can be integrated in the general organisation of the station services.

The types of vehicles used are very heterogenous but naturally adapted as far as possible to local requirements, and in particular to all the services with which each organisation has to deal.

In general, the Railways are not obliged to organise cartage services; however, in France and Algeria it is obligatory for the railway to organise lorry services to serve all places of more than 5 000 inhabitants within at least 5 km. (3 miles) of a station. But collection and delivery services exist on a considerable scale in most countries.

Generally, the cartage services are confined to the towns and their radius of action does not often exceed 12 km. (7 miles). The radius is however 1 600 m. (1 mile) on the Pennsylvania Railroad and Long Island Railroad and 3 200 m. (2 miles) on the British Railways.

Outside agencies are only found in Denmark and Spain in the form of town depots; in Switzerland they are usually in the hands of offices along the lorry routes; in France in the hands of associates or agents, and in Belgium in shops on the lorry routes in the case of rural areas some distance from a station where there are no collection and delivery services.

Consignments are delivered home the day of arrival, or the next day at the latest.

Several Railways allow their clients to decide whether consignments are to be delivered home, or left at the station, but most Railways automatically deliver them if no stipulations have been made to the contrary. Thus in Great Britain, America and South Africa, the freight charge includes collection and delivery charges. The South African Railways stipulate that all goods shall be delivered at certain stations as advertised.

Nearly all Railways organising lorry services are in favour of delivering all consignments without exception in order to simplify work on arrival and reduce the storing of goods. Various Railways doubt whether it is possible to achieve this, as many important clients have their own means of transport.

In general, express goods and postal packages are delivered quickly by the cartage services, or failing this by the station staff or by post.

Goods are collected the day the request is made, or the next day at latest.

The average run of the cartage services varies considerably, the smallest runs being nearly always in the medium sized towns and places not far from the station.

The output of the lorries varies a great deal, from 3 to 10 tons (Switzerland) per 8 hour day.

Horse-drawn vehicles and small lorries are generally staffed by one man, and lorries by two.

Belgium and Finland are exceptions to the general principle of charging for collection and delivery services according to the distance; in their case the towns are divided up into zones.

More goods are delivered home than are collected, the former representing on the average 30 to 40 % of the total traffic and the latter only 5 to 15 %. In the large centres, these percentages are exceeded : in Brussels they are 65 % in the former and 34 % in the latter case.

On the Pennsylvania Railroad and Long Island Railroad, 75.1 % of the parcels traffic is included in the collection and delivery services.

Certain Railways are of the opinion that the rates charged for the collection and delivery services should cover the cost, whilst others on the contrary consider that road competition justifies running such services even at a loss.

As the British Railways justly remark, the costs cannot be strictly compared from

one district to another, and M. SARMA in the general remarks with which he ends chapter III of his report, remarks that in thinly populated area the cost of the lorry services might be considered prohibitive if all the lorry services on each Railway were considered as separate items.

It can therefore be concluded that the development of cartage services in districts with little traffic depends to a certain extent on the possibility of covering, at least making good to some extent, the loss due to rates which do not cover the cost, by receipts from other services where the rates exceed the cost.

The above considerations show that those Railways have reason, who run their own lorry services themselves or have put them in the hands of affiliated companies to supplement the railway services.

The Belgian experiment of hiring lorries from private firms proves that it is possible to conciliate the above points of view and also profit by the lower costs of more modest organisations, without the Railway losing touch with its clients, and with the additional advantage that firms which might be tempted to compete against the Railway become its collaborators.

A considerable number of Railways express their preference for handing over such services to private firms, whilst admitting that in the large towns, running them themselves has its advantages.

When the Railway runs its own cartage services, the vehicles generally belong to the railway and the number of lorries to be run each day is determined according to the traffic of the previous day or that of the corresponding day of the previous week.

In the towns, the routing of the lorries is determined by the addresses of the consignees grouped by sectors. The long distance runs are over fixed routes.

Most countries agree that it is an advantage if the employee making the deliveries helps in loading the lorry.

The data collected on the work done by each lorry makes it possible to determine the cost of the service per lorry-kilometre or per ton-kilometre.

Except when the cartage services are handed over to private firms in which the Railways have an interest (Italy), firms are chosen either by tender or freely by the Railway, according to the price and guarantees offered.

The length of the contract is indefinite in the case of agreements and from 6 months to 10 years in the case of tenders.

Generally, payment is based on the weight and distance.

Several Railways require the types of lorries used to be agreed.

The firm enjoys complete liberty as regards the routing of the services, but in certain cases public demand also has to be considered.

Railway employees do not accompany the lorries.

Either the railway or the contracting firm can be asked to pick up goods, or such demands must be addressed to one or the other. The British Railways consider that the fact that such demands must be addressed to the Railway gives the Railway a measure of control and prevents certain traffic being turned aside to the profit of the contractor.

The contractors undertake to do nothing against the interests of the Railway.

In Great Britain, endeavours are made to reduce the number of contractors at several stations to the minimum. In the other countries, there is generally only one contractor per station or per locality.

Sweden is considering setting up an affiliated Company which will be the sole contracting firm.

The contractor is responsible in principle to the Railway for the goods whilst they are in his charge. The Railway alone is responsible to the public.

17. *The substitution of road transport for terminal services.*

The figures for Belgium are very interesting :

— 78 terminal road services, 32 with collection and delivery services;

— 30 % of the total number of stations are served;

— 15 % of the total traffic is carried by these services;

— 5.7 tons is the average daily output (8 hour day) of each lorry.

The system of « island station » (10 at the present time) being worked in the suburbs of Paris has led to appreciable savings in wagon-days and train-kilometres, and also a saving of 24 to 48 hours in the transit times.

On the Paris-Valence artery the limitation of the railway journey to that between important places, whence road services start to serve the secondary centres has made possible considerable savings in the train mileage and train staff, as well as improving the services as a whole on this line.

18. *Organisation of collection and delivery services in large towns.*

There is nothing particular in such organisation.

B. Concentration of the miscellaneous traffic in a certain number of selected centres (stations) by road or rail between the originating points and the nearest centre station and also to the last centre-station near the destination.

Interest of the scheme for the conveyance of goods traffic.

Organisation of the station centres and of the collection and delivery services.

19. *The advantages and drawbacks of the present organisation (sending and receiving goods by wagon from end to end of the journey).*

The large Railways are most in favour of innovations in this respect, while Railways with little traffic prefer to keep their present organisation. However, certain Railways recognise that the present method is often costly and complicated.

The collection and delivery services are naturally limited by the resources available to each Railway. In fact, in order to serve districts with little traffic at reasonable cost, the charges often have to be below cost and the loss borne by the Railway. The proportion of such districts in each country therefore affects the policy to be followed.

20. *The advantages and drawbacks of the suggested organisation.*

As shown by the considerations under 19 above, the problem is not the same for the large Railways as for those with little traffic, but in principle it may be advantageous to limit, to a greater or lesser extent, according to the characteristics of the country, the railway journey to that between carefully selected places, with supplementary road services to collect and distribute consignments over appropriate routes. The journey time should be shortened in this way, and better services made available in rural districts, which should bring new traffic to the railway.

21. *Selection of the centre-stations.*

The choice of the centre-stations should be determined according to the location of the important railway junctions and roads favourably situated for working the local traffic by lorry services, according to the capacity and equipment of the stations, taking into account the other transport available in the district, and whether local road firms are available, together with the situation and distance away of neighbouring centre stations.

22. *The average radius of action of the road services at centre-stations.*

The limits for the services from each centre station depend upon the density of the roads, the profil of the routes, the

number of stations, localities and depots on each circuit, the volume of traffic in the places served, the staff and equipment available, the road and railway rates in the district. The maximum and minimum limits of the radius of action should be in principle between 20 and 50 km. (12 and 31 miles). The Pennsylvania Railroad and Long Island Railroad consider that the maximum should be 80 km. (50 miles).

23. *The influence of centre stations on the formation of through wagons.*

An appreciable increase in the number of through wagons, with its inherent advantages, is one of the results obtained by organising centre stations. The traffic which can be sent by through wagon is estimated to lie between 50 % and 70 % (80 % in the case of the British Railways) according to the Railway. The minimum load for such wagons varies according to many circumstances.

24. *Organisation of the traffic between centre stations.*

An adequate train service must be organised for the through wagons, taking into account as far as possible the night services and suitably harmonised with the hours of the collection and delivery services. These trains should be run through from one centre-station to the next, or if needs be with a stop in a marshalling yard.

The other wagons will be sent to a transhipment station from which the consignments can be sent by through wagon to their destination centre-station.

The reduction of transhipments to the minimum compatible with proper user of the wagons will lower the cost of handling and facilitate mechanisation.

The organisation of the services in the transhipment stations as well as the kind of equipment depends upon the tonnage to be handled.

The Belgian Railways have decided that the new organisation enables them to save 40 % of the railway ton-kilometres.

25. *The other advantages of setting up centre stations.*

Transit times will be shortened.

The concentration will enable the average wagon load to be increased, and give a faster turn-round of the stock; in the case of Belgium, the saving in the number of wagons used for parcels traffic is more than 30 %.

It is possible to run trains with a higher useful load and better formation.

The cost of handling is considerably reduced; according to the investigations of the Belgian Railways, the tonnage to be transhipped is reduced by two thirds.

From the point of view of the public, the services will be improved, so that new traffic is likely to be attracted to the railway from the districts served by the new road organisation.

26. *Equipment of the centre stations from the point of view of the railway and road installations.*

As remarked above, it is of the utmost importance that the equipment in each centre-station is completely adequate. In general, only relatively simple equipment is required (a single platform is sufficient in most cases), especially as the arrival and departure traffic is not handled at one and the same time. Loading operations should be completed towards 9 p.m., whilst unloading can begin about 5 a.m.

27. *Organisation of the lorry services at centre stations.*

With the exception of the British Railways who prefer to organise their own cartage services, all the Railways are in favour of employing contractors.

The general organisation of the cartage services, the sharing of responsibility, the use made of waybills, as well as the accounts, will be identical with those adopted for the ordinary cartage services. The methods of payment considered are either based on charges according to weight

and distance, or hiring lorries by the day or hour. The latter method has the advantage that the Railway is still in control of the traffic from one end to the other, and consequently direct contact is maintained with its clients without risk of losing them to the road, as well as the extreme simplicity of the accounts with the contractor. On the other hand, in the former case the contractor has an interest in carrying out the work as quickly as possible, but it is necessary to have a clause in the contract stipulating that traffic shall not be diverted to the road by him. The Pennsylvania Railroad & Long Island Railroad consider that payment based on the weight is the simplest and easiest method, while the British Railways consider that this is the most satisfactory method, as this system favours rapid transit.

In the first case, the client can ask either the Railway or the contractor to pick up goods, whereas in the second case the demand is always made to the Railway.

28. *Use of agencies apart from the Railways.*

The concentration of traffic made possible by the use of agencies (at a grocers or « café ») in the different places served by off-lying stations, situated on road circuits, will appreciably affect the lorry services and render considerable service to those clients who cannot profit by collection and delivery services, or whose time can be saved in this way owing to the poor situation of the station.

Although the agent must be paid (a fixed sum or so much per package), the Railway can save staff in this way, especially if the station can be closed to parcels traffic, or when it is badly situated in respect of the town.

29. *Steps to be taken to prevent terminal lorry services becoming excessively costly in districts with little traffic.*

Collection and delivery services should be given up in such districts; if agents are appointed, this will become acceptable.

The transit times must be adjusted so that a sufficient tonnage of goods can be collected for each service, limiting the road services to 2 or 3 a week.

It is recommended to make use of pick-up and distributing wagons for these terminal services, or even of vans on the goods or passenger trains.

30. *Method of charging for consignments.*

The following have all been considered :

a) Application of the usual rates between the consigning and arrival stations, without taking the method of transport into account, and

— if the charge included for collection and delivery services (America, Great Britain and South Africa) no additional charge is made for this;

— if the charge does not include collection and delivery services the corresponding amount is added;

b) Rate between the centre-stations plus special amount for the road journey :

— this being a uniform charge over a given zone;

— or proportional to the distance covered, for example by concentric zones.

c) Between places with stations : rates according to the railway rates between the end stations; between places not actually served by the railway : road rates exclusively, based on the distance and weight.

It would not be reasonable for the new organisation not to maintain the present rating system, or clients would find the charges differed every time it was considered necessary to change the centre-station serving the locality.

The opening of credit accounts for certain clients, as well as allowing agents to accept the money for consignments deposited with them, or else the lorry driver, to the greatest possible extent, will soften the rule that all goods must be sent carriage paid, a principle which the Railways are generally in favour of.

31. *The setting up of centre stations and the transport of express goods, postal packages and perishable goods.*

Certain Railways are of the opinion that the same transport regulations should be applied in the case of postal packages as with other miscellaneous goods. Others prefer to send express parcels and postal packages by passenger train between the centre-stations at the ends of the route, and deliver them by special delivery. Outside normal working hours, such parcels go by passenger train to the nearest station, which is responsible for delivery to the consignee or advising him of their arrival. In some countries, postal packages are carried under special regulations under the aegis of the Post Office.

C. Financial balance sheet.

32. *The investigations made in order to replace railway transport by lorry services.*

Belgium has made a thorough study of this question the results of which are summed up in M. MOULART's Report. According to this, the saving to be expected from the new organisation is about 10 % when the number of centre-stations corresponding to the minimum total cost are in operation (73 centres).

In the suburbs of Paris, the French Railways obtained considerable improvement in the transport of parcels at the cost of additional expenditure amounting to less than 10 % of the receipts, while on the Paris-Lyons-Valence line the savings realised were considerably more than the additional expenditure incurred.

On the British Railways, the improvement of the service rather than economic considerations was the decisive factor in the reorganisation, which is summed up in M. SARMA's Report.

The Pennsylvania Railroad & Long Island Railroad has come to the conclusion that between two given places the use of lorries appears to be more economical than the use of wagons.

On the New Zealand Railways, the savings obtained during a period of 21 months were the equivalent of 71 566 wagons, equal to 178 822 wagon-days.

In Poland and Switzerland, investigations are being carried out, but are not yet conclusive.

33. *The structure and financial results of setting up centre-stations.*

Apart from the elements quoted in No. 32 above, it should be mentioned that in France the switching over to road services. in the Orleans and Chartres districts in the near future aims above all at an improvement in the quality of the service, while in Belgium the partial functioning (13 centres) of the programme (73 centres) is responsible for the net increase in traffic, which is seen in the increase in the tonnage transported from the centre-stations to the corresponding district stations, which justifies the hope that much of the parcels traffic lost to the road will now be recovered. In addition, M. MOULART's summary gives the theoretical balance sheet.

34. *Financial investigations into the operating and equipment of transhipment depots and centre-stations.*

No investigations have been carried out in these matters.

35. *The itemized costs of the elementary operations which affect the transport cycle of parcels traffic.*

In this field, it appears that the information collected cannot be compared as between countries, owing to their heterogenous nature, due to economic, financial and social conditions special to each country, as well as the fact that the scope of the term « itemized costs » is very subjective and open to very different interpretations; it must also be recognised that the information concerning a given country only applies at a given moment. In fact, any modification in the cost of labour affecting railway transport much more than

road transport, any change in customs duties affecting the fuel used by the railway or by road firms, any change in the social benefits granted by one or other method of transport only, etc., invalidate any comparison of the costs of railway and road transport except at a definite given moment.

In this connection, it may be recalled that the British Railways consider that the cost of their road services are not strictly comparable from one district to another, and certain variable conditions have to be taken into account.

36. *The influence of the organisation of centre-stations on claim for delays, losses, theft, and damage.*

The Pennsylvania Railroad & Long Island Railroad found that claims decreased by 50 %, whereas the Egyptian Railways expect to obtain a reduction of 90 %.

On the other Railways the extent of the reduction cannot be estimated until practical experience has been obtained.

III. SUMMARIES.

1. Miscellaneous goods are generally conveyed by through wagons and by pick-up and distributing wagons, or separate pick-up and distributing wagons.

From the point of view of output as well as economy, and in order to improve the service, it is advantageous to adopt an organisation that will enable the user of both stock and labour to be increased, the amount of handling reduced, and the turn-round speeded up. These results are obtained when the number of through wagons reaches the maximum and the load per wagon is also the maximum. These maxima depend upon specific characteristics of the operating conditions on each Railway.

2. The method to be followed by those Railways, which are in a position to do so, is to send the miscellaneous goods by rail between a certain number of centre-stations, carefully selected, whence they can be distributed or towards which they can be concentrated by means of road and/or railway services. Provision must also be made for a possible increase in the traffic as a result of the improved services offered, and a reduction in the number of claims for delays, losses, theft and damage.

3. When dividing up the railway and road transport as a result of the above mentioned method, the cost of each kind of transport must be taken into account as much as possible when the Railway itself operates the road services, or the actual cost to the Railway when a contractor undertakes them.

This division may prove a stage in the co-ordination of rail and road.

4. The above Summary No. 3 strengthens the principle that road transport firms should be subject to the same obligations as the Railway and to the same principles on which railway rates are based — as far as is compatible with their technique and method of operation.

5. Goods should be sent by through wagon, as far as possible from centre to centre, or if this cannot be done by making use of some transhipment centres. Only such stations will have any appreciable amount of traffic to handle.

6. Night work can have a favourable effect on the transit time, so provision must be made for it in those stations where it is necessary.

7. The part played by grouping agents and agents is of advantage to the Railway in the sense that the traffic is concentrated thereby and the output of the stock improved.

The rating benefits generally granted to grouping agents should depend on an undertaking by the latter to limit their activities to the sector given them by the railway and to deliver to the railway all the traffic it can deal with.

The fees paid to agents are made good by the advantages obtained by the appreci-

able services rendered to clients and the possibility of making economies in the staff, either by closing certain stations to parcels traffic, or reducing the number of employees.

8. In organising road services to or from the centre-stations, it is advisable to adopt a solution similar to that introduced in the case of the collection and delivery services.

9. If there is not much traffic on certain sections, the number of road services can be limited to 3 or 2 a week (thereby increasing the transit times), or other existing methods of transport made use of which can carry out the terminal transport without additional cost (vans on passenger or goods trains, light railway services, buses, etc.).

10. The total amounts charged should as far as possible be the same independently of the method of transport used, whether the goods travel by road or by rail to and from the centre-stations.

11. The usefulness of collection and delivery services can be increased to the extent that it is possible to fit them in with the working of the centre-stations.

[656 .225 & 656 .261]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

ENLARGED MEETING OF THE PERMANENT COMMISSION
(LISBON, 1949.)

QUESTION III.

Transport of miscellaneous goods.

Concentration in a certain number of selected centres (stations) of miscellaneous traffic, transport by rail between centre-stations, by road or rail between the originating point and the nearest centre-station, and also to the last centre-station near the destination.

Interest of the scheme for the conveyance of goods traffic.

Organisation of the station-centres and of the collection and delivery services.

Financial results of the scheme.

SUPPLEMENT TO REPORT, (*)

by G. MOULART,

Ingénieur en chef, chef du service technique de l'Exploitation à la Société Nationale des Chemins de fer belges.

The situation from the point of view of the miscellaneous goods traffic on the Hungarian and Mozambique Railways is similar to that on other Railways of the same size.

The goods are sent by pick-up and distributing wagons or through wagons, which are dealt with intermediately.

In Hungary there are 8 transhipment stations at which parcels are regrouped. The platforms are 10 m. (32′9¾″) wide and their length is based on an allowance of 1 m² (10.76 sq. ft.) per 100 kgr. (220 lbs.) of goods.

The transport conditions and transit times are similar to those found on other Railways.

The statistical data relative to the three above mentioned countries are summed up in the following tables.

The results are very close to those obtained on the other Railways as previously reported, and call for no remark, except that the large proportion of the

(*) See *Bulletin of the International Railway Congress Association*, April 1949, p. 229/1.

COUNTRY	Extent of system in km.	Total population (in millions)	Number of stations			Population served by stations with collection and delivery services	Average daily tonnage	
			Total	Open for parcels traffic	With collection and deliv. services		per station	per 1 000 inhabitants
Hungary	8 081	20	1 244	1 073	97	3.1	1.57	0.084
Mozambique . . .	1 370	—	52	52	3	—	—	—
Netherlands	3 351	7.1	563	284	244	5.9	10.68	0.427

COUNTRY	Miscellaneous traffic			Complete loads		
	Tonnes/day	No. of consignments	Average weight per consignment kgr.	Tonnes/day	No. of consignments	Average weight per load kgr.
Hungary	1 684	—	—	49 168	—	—
Mozambique	—	—	—	—	—	—
Netherlands	3 033	49 124	62	23 824	—	—

Comparison of average daily traffic for miscellaneous goods (MG) and complete wagon loads (CW).

COUNTRY	Tonnes			Tonnes-Km.			Receipts			Receipts per Tonne-Km.		
	MG	CW	$\frac{MG}{MG+CW}$ %	MG	CW	$\frac{MG}{MG+CW}$ %	MG	CW	$\frac{MG}{MG+CW}$ %	MG	CW	$\frac{MG}{CW}$
Hungary . . .	1 684	49 168	3.3	233 319 (gross)	7 941 419 (gross)	2.85	182 614 forints	2 211 400 forints	7.6	0.782 forints	0.278 forints	2.81
Mozambique .	—	—	—	—	—	—	—	—	—	—	—	—
Netherlands .	3 033	23 824	11.3	—	—	—	66 205 florins	106 521 florins	38.3	21.82 florins (per T.)	4.47 florins (per T.)	4.9

population served by collection and delivery services in Holland (83 %) should be noted.

Hungary is against transport grouping agents, as in her opinion these have not proved satisfactory. The lorry services are entirely in the hands of private firms, but are limited on account of the bad state of the roads. An extension of these services and the creation of centre-stations could only be justified by an appreciable increase in the traffic and an improvement in the roads.

From the point of view of the routing of parcels traffic, the *Netherlands Railways* are in an altogether special position. The whole of the traffic travels by through wagon between the 38 centre-stations : the average load of these wagons being 4 tons.

The distribution and collection of consignments to and from the centre-stations is carried out by means of :

— complete wagon loads for 60 sub-stations (the most important stations after the 38 centre-stations);

— by lorry or tram to other destinations.

500 lorries (4½ ton motor vehicles) together with 420 horse-drawn vehicles are used for the cartage services. These are organised by an associated company and their radius of action varies between 18 and 46 km. (11 to 28 miles) according to the importance of the centre.

This Company frequently makes use of local transport firms.

There are no transhipment stations.

Between places of small importance, consignments are delivered and collected by means of an outside agent.

In short, all the traffic is concentrated in the centre-stations, the pick up and collecting services being mixed services, using either lorries, or other existing methods of transport according to circumstance and the amount of the traffic in question.

The Netherlands Railways, which have been organised in this way since 1934, have not drawn up any financial balance sheet to compare this method with that using the railway from one end of the journey to the other. They report however that the number of wagons used daily for the parcels traffic has been reduced from 3 900 to about 1 000.

The total daily tonnage being of the order of 3 000 t., the average load per wagon is approximately 3 t.

In order to improve the general output of the stock, the Netherlands Railways propose to reduce the number of centre-stations from 38 to 21, which will obviously entail an extension of the road services.

This agrees with the theoretical investigation carried out by the Belgian Railways, although in the case of Holland the reduction to 21 centres would appear to be excessive and likely to increase the total costs appreciably above the minimum.

The relatively small traffic handled by the centre-stations does not justify any special equipment, but night work is essential if the transit times are to be maintained (2 days for slow goods, and 1 day for express goods). To reduce the cost of handling operations, the Netherlands Railways are trying out a new installation : a mobile platform with moveable floors. The wagons are fitted with rails to take the moveable floors (6 per wagon). The sizes of these floors correspond to those of the lorries.

The goods, after being sorted into their respective lorry groups, are loaded on to the moveable floors of the wagons.

The wagons are then taken to an unloading yard where the floors and their loads are moved into the lorries drawn up in position to receive them. In this way a lorry, which arrived empty, can leave loaded ten minutes later.

This arrangement appears to be of value only if the lorries have to make several trips a day (which does not often happen), or if the storage space is insufficient for the traffic to be handled.

The rates are calculated between the theoretical departure and arrival stations, plus the charge for collection and delivery services if necessary. The method of transport used has no effect on the rates at all.

Finally, the Netherlands Railways are not at all in favour of grouping agencies, and only make use of them when road or water competition makes such steps necessary.

To sum up, the organisation of the miscellaneous goods traffic on the Netherlands Railways conforms very closely to that under consideration and confirms most of the summaries given in the general report.

[621 .337]

Individual axle drive.

Mechanical systems used on electric locomotives and railcars, with an indication of the results obtained in service on railways of all kinds,

(Continued)*

by ADOLPHE-M. HUG,

Consulting Engineer, of Thalwil, (Zurich) Switzerland.

SUPPLEMENT. — APPENDIX.

Types of mechanism which have been introduced, or first described, since this survey was commenced in 1947.

N. B. — *This supplement completes, on the one hand, the author's work dated 1932/33 on the Individual axle drive (Commande individuelle des essieux), and on the other hand that published serially in the* Bulletin of the International Railway Congress Association, *Nos. of September, October and December 1947, February, April, July, October and November 1948, and of January 1949.*

The subject-matter is, therefore, as far as possible complete up to the end of 1948.

General remarks on Chapter I

GENERAL

(also of Cde. Indiv.)

To present as complete a survey as possible, further mention must be made of an instance in which *locomotives with coupling rod drive,* used on a large scale, have given and continue to give good results in service on large classes over a number of years.

This is the 1-C-1, known as class D, of the Swedish State Railways, SJ., already mentioned on several occasions (single phase current, 15 kV., 16 $^2/_3$ cycles).

These locomotives, 333 of which are in service — the first 50 since 1925, are numbered in the series 101 to 599 [171]. As shown in figs. 276 and 277, there are no oblique rods involving a vertical component but only *horizontal* rods. The arrangement of the drive is therefore similar to that of the 1B+B1, Be $^4/_6$, series 12302-12348 (originally 11302)

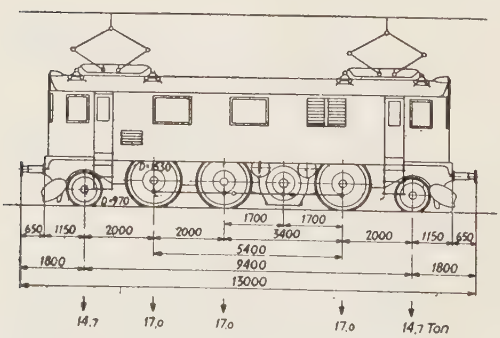
(*) See *Bulletin of the International Railway Congress Association,* Nos. of September, October and December 1947, pp. 823, 885 and 999 respectively, Nos. of February, April, July, October and November 1948, pp. 73, 227, 403 and 591 respectively, and January 1949, p. 71.

[171] In 1938, there were in the series, locomotives Nos. 101 to 150, 153 to 162, 171 to 245, 291 to 391 and 401 to 477, that is 283 locomotives. — The transverse play of the middle driving axle is normally 2 × 30 mm. (2 × 1$^3/_{16}$"). This has been experimentally reduced.

locomotives of the Swiss CFF, which were put into service in 1921/22 for working passenger trains ($v = 75$ km./h., hourly rating 2 400 H.P.).

These Swedish 1-C-1 locomotives ([172]) have an hourly rating of 2 000 H.P., a maximum speed in service of 100 km./h. (62 m.p.h.) (some are 75 km./h. [46 m.p.h.] with a rating of 1 700 H.P.) and a tare of 80 tons; the two motors drive the same gear wheel, mounted between the second and third driving axles, on

Photo ASEA.
Fig. 276. — D class locomotive, 1-C-1 type, séries 101 of the Swedish State Railways, SJ, with a passenger train in Falköping station.



SJ.
Fig. 277. — Dimensioned sketch of locomotive in fig. 276.

the hollow shaft which is set at the same height above rail level as the rod-coupled axles; the driving rods of the two neighbouring axles, as well as the coupling rod for the second and leading axles, rest in a horizontal plane. Two engines which were for a time converted for 120 km./h. (74 m.p.h.) (by a big reduction in the gear ratio) have been reconverted for 100 km./h. In addition, the two even earlier locomotives of the Kiruna-Riksgränsen line, type 2C+C2, series « Pb », have been separated and converted to the same type, 1-C-1, thus

([172]) See the publication by the ASEA Co. of Vasterås, 1926, Electrification of the Swedish State Railways; the main line Stockholm-Gothenburg. — *Elektrische Bahnen*, Berlin-Munich, Apl. 1936, p. 92, « Die elektrischen Lokomotiven der Schwedischen Staatseisenbahnen », J. ÖFVERHOLM, with a comparative table of maintenance and works costs of electric locomotives, of the SJ (Sweden), DR (Germany) and CFF (Switzerland).

giving 4 locomotives although the power has been somewhat reduced.

The electrical equipment of all these was supplied by the ASEA (Allmänna Svenska Elektriska Aktiebolaget) of Vasterås. The mechanical parts of all these locomotives was manufactured by one or other of the three firms :—

Nydquist & Holm AB.«NOHAB», Trollhättan,

AB.Motala Verkstad, Motala,

AB.Svenska Järnvägsverkstädarna, Vagn- & Maskinfabriken, Falun.

The actual cost of maintenance of these locomotives is low, due partly to their fairly simple design and partly to the large number of them and the experience gained in their upkeep (SJ Works at Malmö) [173]. It is considered, however, that apart from the shunting engines with 3 coupled axles, and particularly for locomotives working at speeds of more than 100 km./h., it is greatly preferable to use an appropriate flexible individual drive.

For comparison, it may be noted that in 1938 one of these 1-C-1 type, class D, locomotives cost only 190 000 crowns, whilst a class F, 1-D_0-1 (figs. 91 and 92) built, it is true, for higher power and speed, cost at the same time 450 000 Swedish crowns.

It may also be remarked that the Swedish Railways are somewhat handicapped in their development owing to the low weight of rail on main lines (40 kgr./m. [88 lbs. per m.] or 45 kgr./m. [100 lbs. per m.] on some improved sections), which restricts the maximum load on driving axles to 17 tons. Finally, and as a supplementary note, the return current on the SJ is not carried by the rails but on an overhead wire supported by pylons, as shown in the illustration of the new express electric sets (fig. 331, in this Supplement).

Still within the scope of these general remarks, we have mentioned on the page containing fig. 5 the convenience, if not the necessity, of providing for traction transmissions, *heat-treated and normalised gears*. It is considered appropriate to mention a particularly interesting gear of the Als-Thom type for the French SNCF (see fig. 278). These gears, tempered and normalised, on the « Maag » machines, have a ratio of 21 : 87 with a modulus of 10.968; they are designed for a power of 600 H.P. (per motor, or per axle) for 800 : 194 r.p.m. In view of the small section of the geared rim (as a result of the small available space), as well as the power and speed, this gear is noteworthy.

These gears are fitted to the B_0B_0 locomotives, Nos. 8101-8236, of SNCF series 8001 (formerly 0401 series), a number of which are still undergoing erection or fitting. These engines have an axle loading of 23 tons with Isothermos (Athermos) boxes; they will be mentioned again in Chapter II. The geared rims are flexibly mounted on springs, the motor being only partly suspended. The speed limit is 105 km./h. (65 m.p.h.).

With regard to the converted locomotives 1-B-1 of the Rhaetian Railway (Rh.B.) in Switzerland, one of which is shown in fig. 6, the small table in the text shows the considerable progress which has been realised in 35 years of electric traction. The converted loco-

---

(173) See Öfverholm, note (172), regarding works costs. *Elektrische Bahnen*, Apl. 1936, « Stangenantrieb oder Einzelachsantrieb bei elektrischen Lokomotiven? », by Kühne.

motive has twice the power and a 45 % increased speed, both achieved with 15 % reduction in weight. The bibliography of these locomotives is also completed (174).

Of the seven original Rh.B. locomotives of this type, put into service in 1913 (175), five have been converted, that is four in accordance with fig. 6 (Nos. 211-214) and one, combined with a

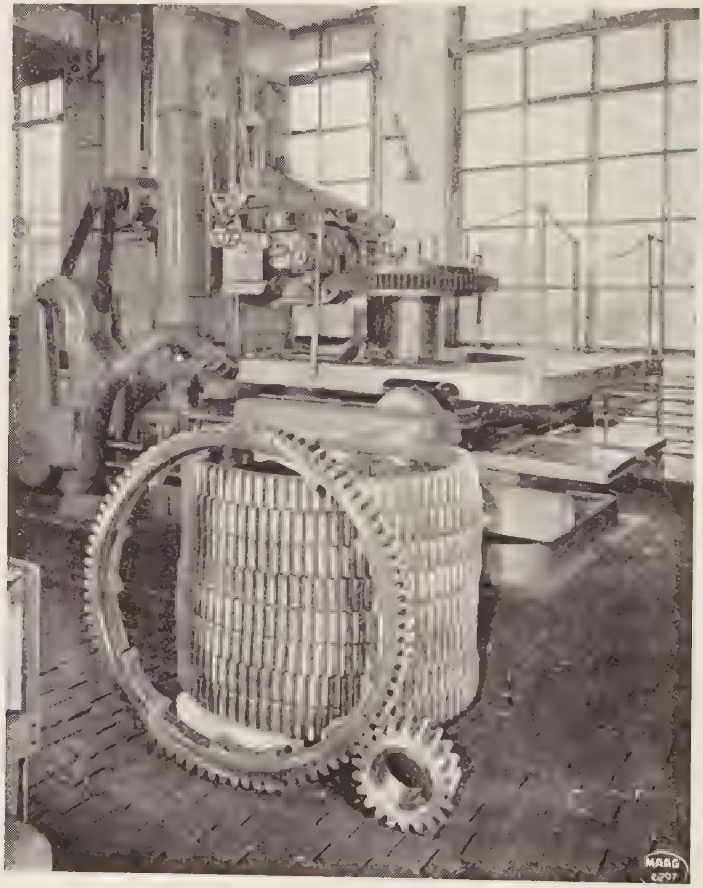


Photo MAAG.

Fig. 278. — Case-hardened, tempered and normalised gears for mounting on the spring-loaded gear-wheel centres (in a similar manner to fig. 7) for B_0-B_0 locomotives, series 8101, of the SNCF (built by Als-Thom). Transmission ratio 1: 4: 143.

(174) See *Revue Brown Boveri*, Baden (Switzerland), Oct./Nov. 1945, p. 407. — *Bulletin Technique SLM*, Winterthur, Oct. 1944, pp. 26-27.

(175) See « Rhätische Bahn, der elektrische Betrieb auf den Linien des Engadins », Rh.B. edition (Coire), (Orell-Füssli, Zurich), pp. 33-36 and figs. 21-26.

battery of accumulators, to enable it to operate equally on DC or single phase AC supplies [176]. These converted locomotives are for use as shunting engines or for working light trains.

General remarks on Chapter II

NOSE-SUSPENDED MOTORS

There are no special points to note, and it is sufficient to reiterate the general advantage, particularly in operating conditions such as exist in Europe and most countries [apart from North America [177] where rails are generally very heavy] of completely suspending the weight of the motor, apart from its effect on track maintenance costs.

Referring to figs. 11 and 12, it is noted that locomotives under construction, for single phase current of industrial frequency, no longer have one motor per axle (see fig. 238 and the following page, also remarks under Chapter V of this Supplement). The dimensioned sketch, fig. 238, is not, however, definite.

It can also be said, with regard to the B_0+B_0 (B_0-B_0, respectively) in fig. 9 and what is stated in the right-hand column of the page between figs. 9 and 10 [see note [114] concerning adhesion] that the SNCF are still having built for them large numbers of these locomotives [178]. With those ordered in 1945, there will be about 600, of 10 main types, differing somewhat, the first 123 dating from 1923/25 [179].

All these locomotives have nose-suspended motors (12 metadyne, shunting locomotives, v_{max}-speed = 50 km./h. [31 m,p.h.]) and are provided, according to the series, for passenger or freight trains, with maximum operating speeds of 70-115 km./h. (43-71 m.p.h.). It is stated (fig. 9 page, and following page) that behaviour when running is better with the spring-loaded flexible geared rim (figs. 7 and 278) and the costs of maintenance lower with sprung monobloc (instead of divided) geared rim, the provision of unilateral or bilateral gears having no appreciable influence.

The axle-load of these BB locomotives is 18-20 tons, according to the series, apart from the 8001 series, already mentioned, of 1945, which has the new 23 tons, main line, SNCF standard, although this load can, by reducing ballast, be lowered to 20 tons [180]. In addition, this series has no axlebox slides or horn-stays for locating the axleboxes, but is provided with articulated push-rods on rubber silent-blocks [fig. 5 of the first

(176) See *Economie et Technique des Transports*, Lucerne, Nos. 68-70, pp. 35 and 58-61, in « The Rhaetian Railway; improved and modernised rolling stock, 1939-1946 ». J. BERTSCHMANN (French and German).

(177) Note that even in the U.S.A. the tendency to suspend fully the whole weight of the motor is growing daily. The rails of the Pennsylvania RR, for example, are up to 82 kgr./m. (180 lbs. per m.) but the axle load may rise to 36 tons for certain locomotives (30 tons with electric traction).

(178) The Netherlands Railways (NS) have ordered from Als-Thom, 25 B_0+B_0 modern locomotives, similar to those of the SNCF, also with « Athermos » boxes but with silent-block mechanism. See further.

(179) See *Le Génie Civil*, Paris, No. 3220, 1-1-48, pp. 1-6, 10 figs., diagrams and tables, « Les nouvelles locomotives électriques françaises BB-0401 », Y. MACHEFERT-TASSIN. — *Amis des Chemins de Fer*, Paris, Mar./Apl. 1937, p. 39.

(180) 185 locomotives of this type are under construction (Autumn 1948), i.e. Nos. 8101-8285, all as the prototype 8001 (ex 0401). See note (179).

publication mentioned in note ([179])]. The axleboxes are Athermos type.

Since we have already mentioned several times the forced lubrication Isothermos axlebox (and the improved Athermos, with a special bearing for distributing the oil through multiple channels), two illustrations are included, viz., fig. 279, showing the forced lubrication principle to a box on the journal (frame outside the two wheels of an axle) and 280 showing a locomotive carrying axle with inside boxes (for inside bogie or bissel truck frame); the latter are necessarily two-piece boxes for dismantling purposes (see figs. 8, 12, 21, 37, 38, 51 to 53, 80, 81, 85, 87 to 90, etc.).

As a final point, in connection with Chapter II, relating to « tramway » type suspended motors, it may be mentioned that the SNCF intends to carry out tests with flexible wheels on several of the BB locomotives mentioned.

A description, with fig. 255, has been given of the SAB flexible wheel for tramways. A new system has recently been developed by the SAGA (Pirelli) Co. of Milan, and this will be discussed later.

The SNCF hopes, by fitting these flexible wheels to achieve a reduced maintenance cost of their nose-suspended motors. The trial is to be carried out, for *each* of the two types (SAB and SAGA) on eight driving axles, or on two locomotives of the series 8101-8236, now under construction. This trial is very interesting, since it embraces axle loads up to 23 tons (11.5 tons per wheel) on high-power electric locomotives; for this purpose several concentric rubber discs have been provided for each system, which differ inasmuch as the SAB has a tyre forming part of the wheel centre (separate from the boss, see fig. 255), whilst the SAGA has a circular metal

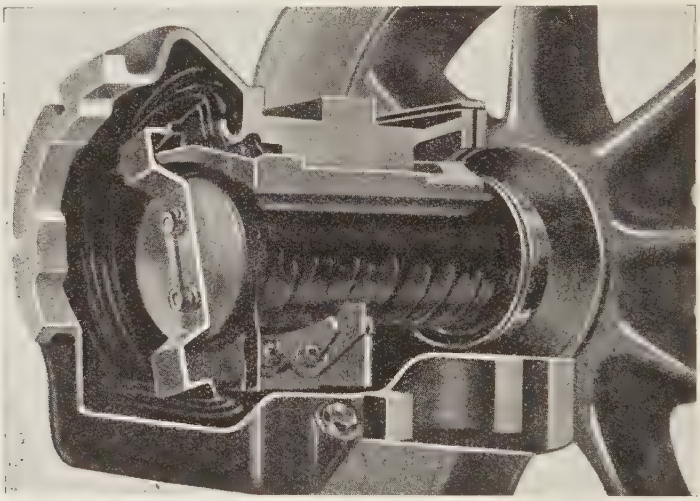


Photo Isothermos.

Fig. 279. — Isothermos axlebox — Athermos type — part section showing how the forced lubrication is effected in the box on the journal.

centre connected to the boss, the outer metal walls, on the other hand, being connected to the rim, generally a monobloc with the tyre.

This problem has been set to the agents in France (SAB and Pirelli-Paulstra). It would be premature to discuss the question here at present and consequently it will be deferred; the Author of this article has however, seen some of the projects for meeting the case.

$2\text{-}D_0\text{-}2$ type, series 501 of the SNCF, Western Region (former Etat).

The following main particulars may be added to the text under item *b*) to the right of fig. 16 :—

Length over buffers . .	17.780	m.	(58′4″)
Length of body	16.590	»	(54′5 1/4″)
Width of body	2.980	»	(9′9 3/8″)
Total wheel-base . . .	14.400	»	(47′2 3/4″)
Rigid wheel-base . . .	6.060	»	(21′7 7/8″

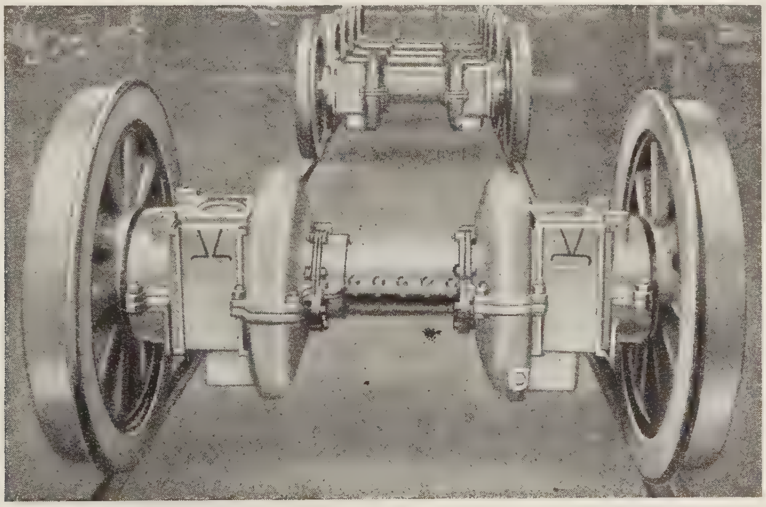


Photo Isothermos.

Fig. 280. — Locomotive carrying axle, with inside frame, showing the divided Isothermos inside boxes.

General remarks on Chapter III

DRIVES WITH PUSH-RODS AND ARTICULATED MECHANISM

Ad. A. — With regard to the *Buchli* (Brown Boveri) mechanism, the bibliography of the locomotives shown in fig. 13 is completed (181), 25 engines,

Distance between bogie centres . .	11.740	m.	(38′6 1/8″)
Bogie wheel-base . . .	2.400	»	(7′10 1/2″)
Dia. of driving wheels .	1.750	»	(5′8 7/8″)
Dia. of carrying wheels	0.970	»	(3′3″)

(181) See *Revue Générale des Chemins de Fer*, Paris, Sept. 1938, « L'électrification de la ligne de Paris au Mans » (locomotive 2.D.2, pp. 102-105).

Weight in working order . . .	129.5	tons	(127.454 Engl. t.)
Adhesive weight . .	80	»	(78.734 Engl. t.)
Weight of mechanical part . . .	80	»	(78.734 Engl. t.)
Weight of electrical part . . .	48	»	(47.241 Engl. t.)

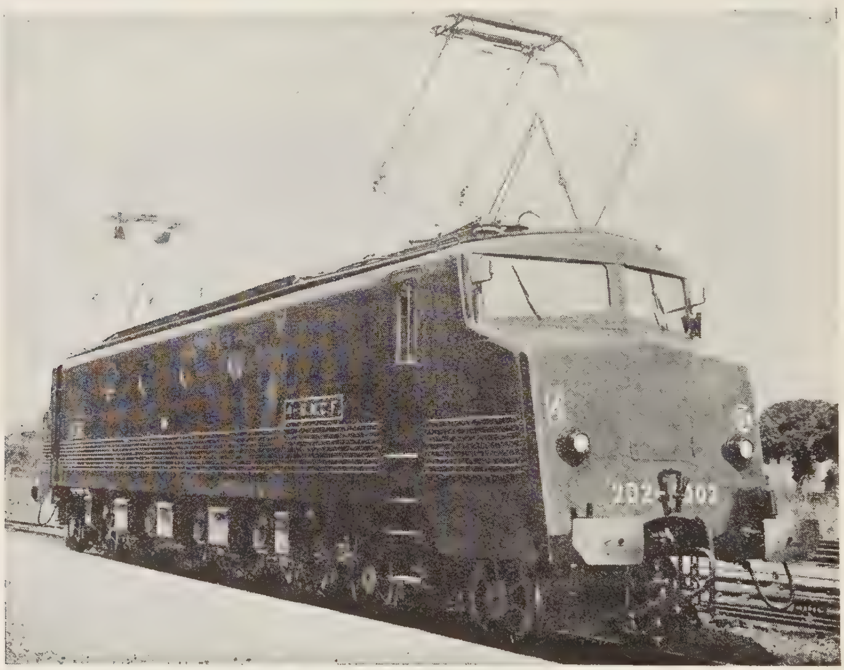


Photo Als-Thom.

Fig. 281. — Locomotive of the series 5302-5306, with Als-Thom silent-block mechanism, new streamlining, 4 500 H.P., 150 km./h. (93 m.p.h.), 138 tons (Isothermos boxes).

No. of motors	4	
Hourly rating	3 740	H.P.
Gear ratio .	1:231	
Max. operating speed .	130	km./h. (80 m.p.h.)
Date put into service . .	1937	

The 73 locomotives mentioned under *b*), right of fig. 16, carry the numbers 501-545 (S.W. Region, SNCF, former P.O.-Midi), 5546-5550 (also S.W. Region) and 501-523 (W. Region, former Etat), they have characteristics as detailed above. It may also be noted that the 5 locomotives No. 5546-5550 mentioned above have a maximum operating speed of 150 km./h. (93 m.p.h.) instead of 130 km./h. (80 m.p.h.) for the remainder.

These are the locomotives which for long worked, and with others continue to work, the fastest trains in France (Paris-Austerlitz to Bordeaux). Their streamlining (outer form) is similar to the locomotives in fig. 281.

The electrical equipment of the 73 locomotives was supplied by the Electro-

Mécanique Co. (Brown Boveri license, France) and the mechanical parts (apart from the first two, Nos. 501 and 502, of the P.O., which were from SLM-Winterthur) [182] were obtained from the Fives-Lille Co.

Photo Als-Thom.

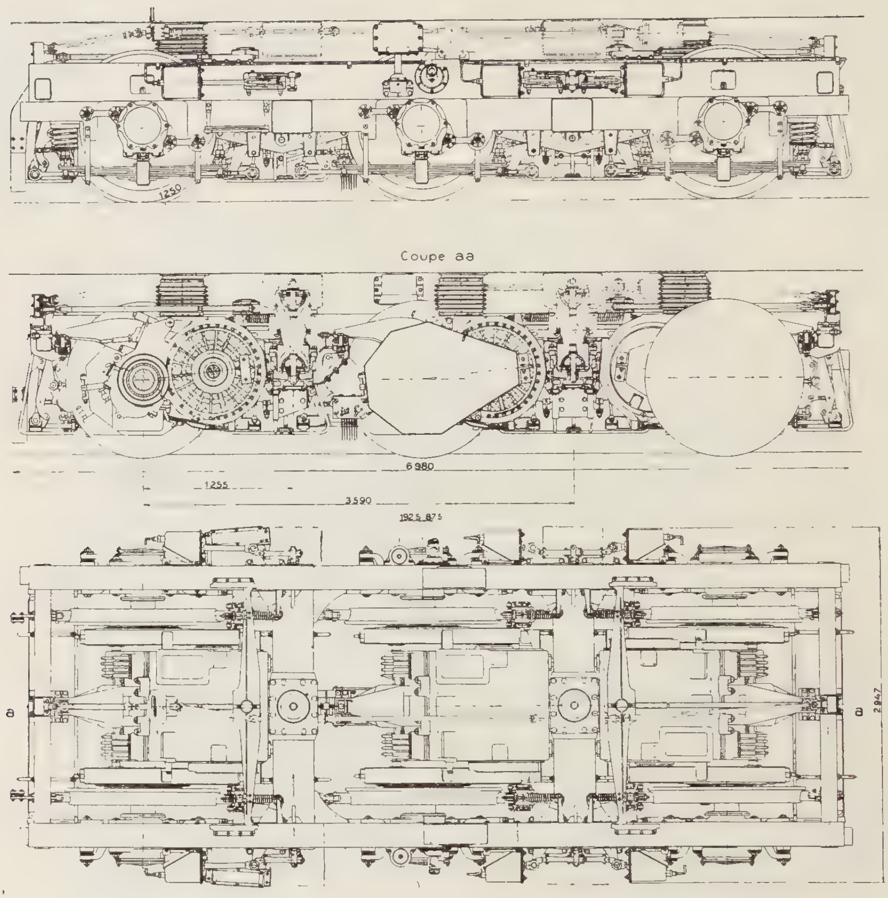
Fig. 282. — Prototype locomotive No. 7001, SNCF-4, type C_0-C_0 for express trains, 3 300 H.P., 160 km./h. (100 m.p.h.), 96 tons; axle load 16 tons (Isothermos boxes).

All these locomotives have bilateral gears and drives.

The average mileage in 1943 was 2 million km. (1 242 000 miles) for the S.W. Region locomotives and 700 000 km. (497 000 miles) for the W. Region (Etat) locomotives. The interval between general repairs was 200 000 km. (125 000 miles). Wear of the gears was insignificant, the large gear wheel is of cast steel, 55 kgr. (34.92 t. per sq. inch) and the pinion is 75 kgr. (47.62 t. per sq. inch) carbon steel.

The first two machines were put into service in 1925, Nos. 503 to 545 from 1934 to 1938, Nos. 5546 to 5550 in 1942.

[182] See *Revue Générale des Chemins de Fer*, Paris, pp. 207-221, 1928, reprint of the work « Electrification partielle du Réseau de la Compagnie d'Orléans », H. PARODI. — See also table on p. 42 of Mar./Apl. 1945, edition of the review *Amis des Chemins de Fer*, Paris, A. GACHE.



Plan Als-Thom.

Fig. 283. — Two-pivot bogie in elevation, longitudinal section and plan, of the C_0-C_0 locomotives Nos. 7001-7002 (see fig. 282). Drive mechanism as in figs. 285 and 286, but with bilateral gears.

Ad. D. — *Als-Thom* mechanism.

We may note, firstly, that the five 2-D_0-2 locomotives already described (which could also be designated 2-BB-2 since the driving axles are really coupled in pairs by the gears) have a different appearance (outer cowling) from those in fig. 22 (prototype No. E.703). An illustration is given in fig. 281 [183].

Apart from these five, or six, locomotives described on the pages containing figs. 21 to 31 (fig. 23 to 29 and 31,

[183] See the review *Amis des Chemins de Fer*, Paris, Jan./Feb. 1945, p. 18, « Réalisations récentes de matériel roulant électrique à la SNCF », A. GACHE. See also the conclusion of note [182].

the « E.703 », figs. 22 and 30), the transmission mechanism of which is already shown in figs. 23, 25, 26, 29 and 30, some later applications of the same axle-driving mechanism with silent-blocks can be described :—

1) Two electric locomotives, type C_0-C_0, Nos. 7001 and 7002, with a wheel diameter of only 1 250 mm. ($4'1^7/_{32}''$) have recently been built by Als-Thom at their Belfort Works for the SNCF [184]; they were ordered in 1946 (see fig. 282). The driving mechanism of these engines is identical with that in figs. 285 and 286 (see item 2) hereafter).

With this new type, it is hoped to secure the following advantages :

— increased adhesive weight (by comparison with the 2-D_0-2) from 80 to 96 tons, and a reduction in axle load from 20 to 16 tons (with a view to reducing fatigue in the track, particularly at higher speeds);

— tractive characteristics, which under economic conditions, will enable the haulage of fast passenger and also freight trains;

— satisfactory behaviour on the track with high-speed trains.

These locomotives have some quite new points of design. The body is carried on two bogies, each with three motors, and each bogie has *two* inclinable pivots in double sockets, as shown in fig. 283. These inclinable pivots are designed to provide a very convenient self-aligning lateral displacement and this arrangement is simpler than swing bolsters.

The three motors fitted in each bogie are of the fully-suspended type with

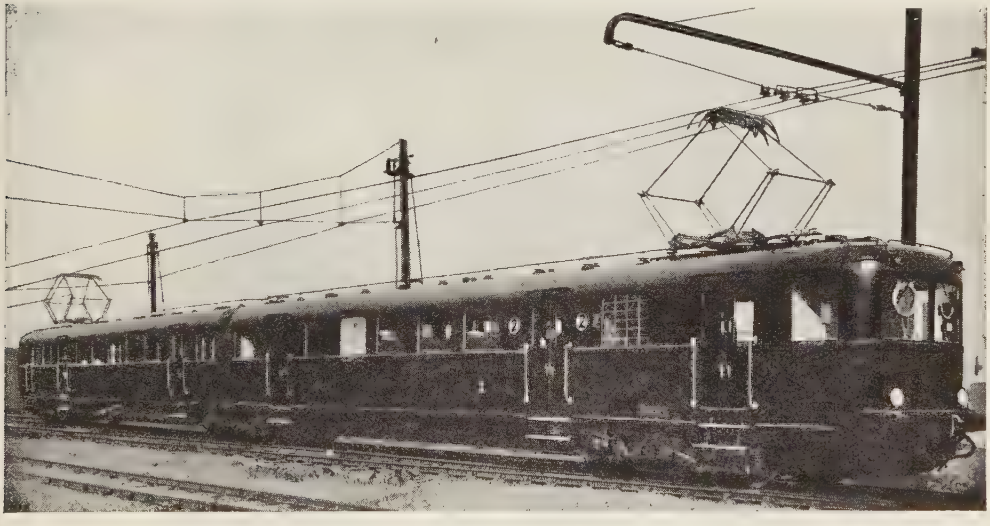


Photo Als-Thom.

Fig. 284. — Articulated electric rail motor set of 2 coach units, series 23.071, for speeds of 140 km./h. (87 m.p.h.); all axles driving (Isothermos boxes).

[184] See the review *Amis des Chemins de Fer*, Paris, Mar./Apl. 1948.

hollow shafts and silent-blocks as already mentioned.

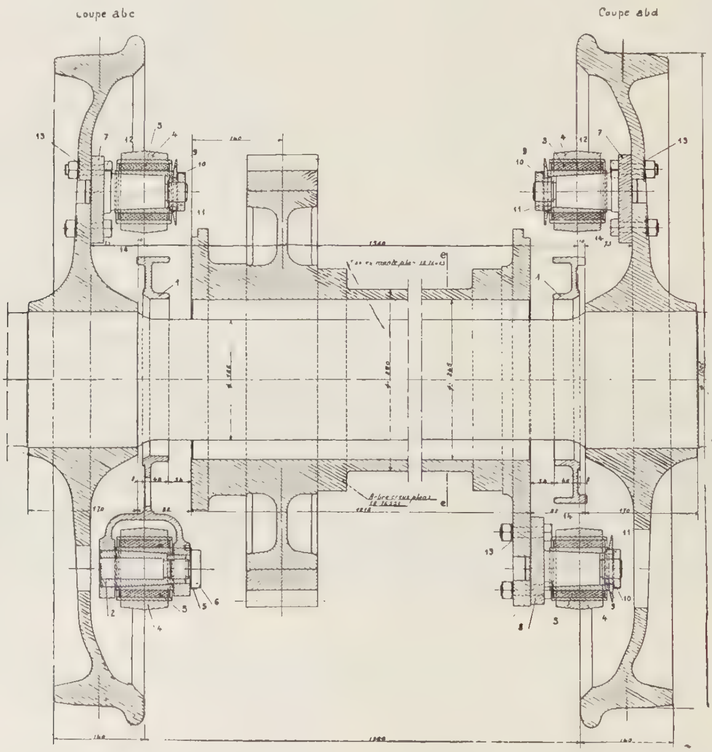
It will also be noted that the use of two pivots per bogie also allows the automatic spreading of the load on the axles, which is always a complicated question with three axle driving bogies with one pivot [185]. Fig. 283 is a drawing of this bogie.

The hourly rating of 3 300 H.P. of locomotives Nos. 7001 and 7002 covers an average line tension of 1 350 volts. The principal dimensions of the locomotives are as follows :

— length over buffers 18.834 m. ($61'9^{13}/_{32}''$)

— rigid bogie wheelbase . . . . . . 4.845 » ($15'10^{49}/_{64}''$)

— total wheelbase . 14.140 » ($46'3^{1}/_{2}''$)

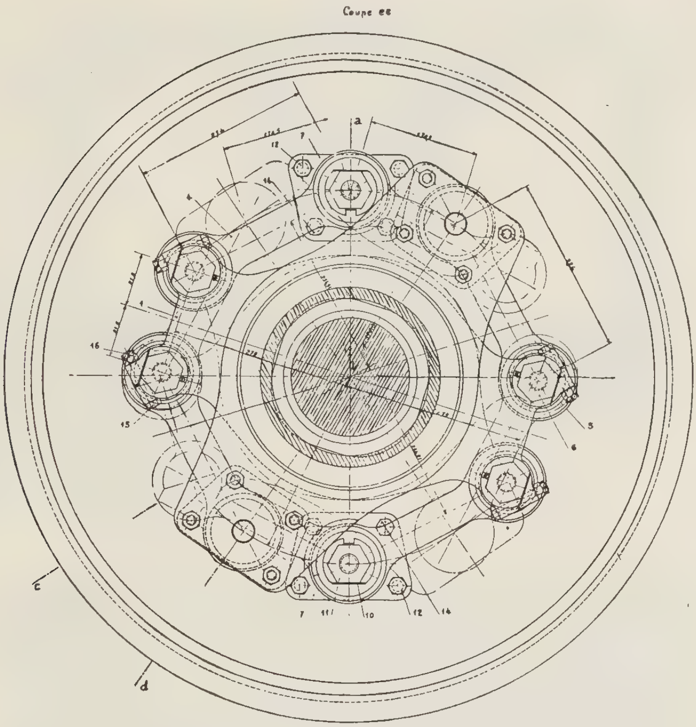


Plan Als-Thom.

Fig. 285. — Axle of set in fig 284, section through centre; the gear wheel being solid with the hollow shaft.

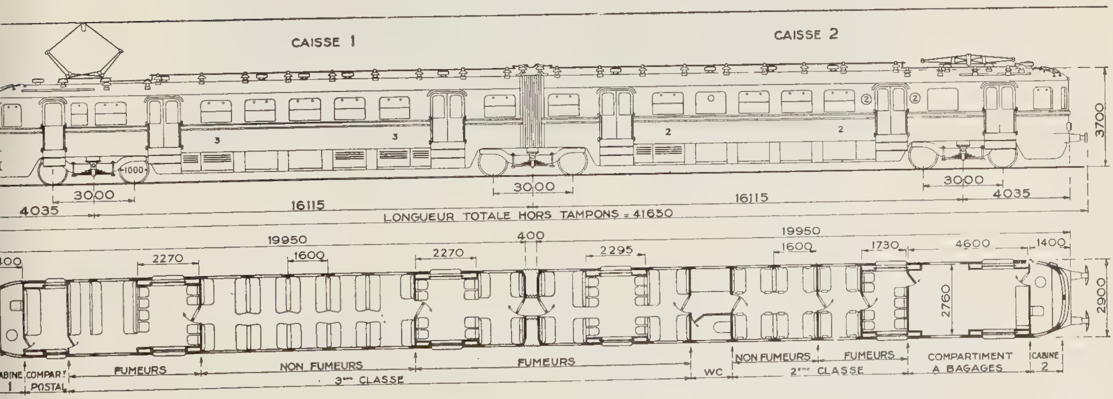
1 = Floating ring linking wheels.
2-4 = Silent-blocks.
5-6 = Links for fixing silent-blocks to floating ring.
7 and 9-14 = Links for fixing silent-blocks to the wheel.
8 and 9-14 = Links for fixing silent-blocks to the hollow shaft.
Bilateral drive : unilateral gears.

[185] See the note published by Als-Thom, Paris, « Locomotive électrique Alsthom, type CC, à grande vitesse », July, 1947. — *Amis des Chemins de Fer*, Paris, Mar./Apl. 1948, pp. 27-32, 6 figs., D. CAIRE.



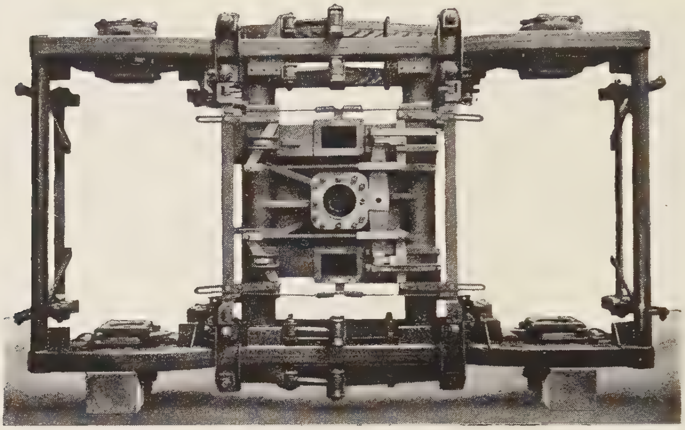
Plan Als-Thom.

Fig. 286. — Front elevation of fig. 255; axles of sets in figs. 284 and 287, showing the axes of the section (axle and hollow shaft in section).



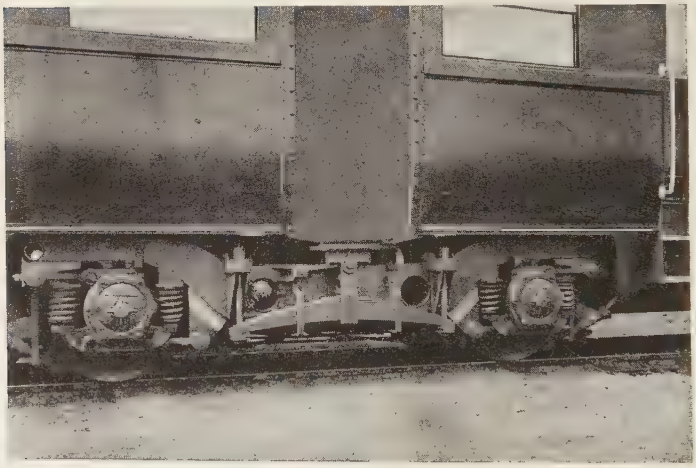
Cliché Als-Thom.

Fig. 287. — Dimensioned plan and elevation of the sets in fig. 284.



Cliché Als-Thom.

Fig. 288. — Bogie frame, seen from above.
Same sets as shown in figs. 284 and 287.



Cliché Als-Thom.

Fig. 289. — View of central bogie under the articulation of the sets in figs. 284 and 287.

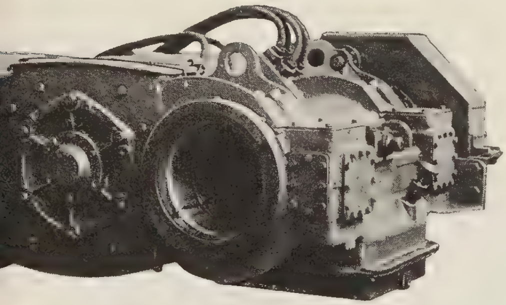
2) The articulated, two-vehicles on three bogies, sets of the SNCF, S.W. Region. These are the two double motor coaches Nos. 23071 and 23072 ordered from Als-Thom in 1938, but which, owing to the war, were not put into service until 1947 ([186]).

Fig. 284 shows one of these sets in

([186]) See *Revue d'Electricité et de Mécanique*, Paris, No. 72, Jan./Mar. 1948, « Les automotrices à caisse double de la SNCF, Région S.-O. », 14 p., 17 figs. A. LÉGER.

service on the line. All the axles are driven and the set is of 1 170 H.P. hourly rating at an average line tension of 1 350 V. D.C., or 200 H.P. per motor.

The empty weight (tare) of these double motor coaches is 80 tons and the capacity is 300 passengers, with 110 seats.



Cliché Als-Thom.

Fig. 290. — Traction motor, hollow shaft and gears of sets in figs. 284-289.

The axle load of the vehicles when fully loaded is about 17 tons.

The maximum operating speed is 140 km./h. (87 m.p.h.). During acceptance trials in July, 1947, a speed of 170 km./h. (105 m.p.h.) was attained and the stability on the road was excellent.

The driving mechanism, bilateral with unilateral gears, is shown in figs. 285 and 286. It is similar to that described for the locomotives but the arms of the floating ring and the push rods are shorter, since the wheels are only 1 000 mm. ($3'3^3/_8''$) whilst the diameter of those under the locomotives, shown in figs. 22, 29 and 30 is 1 750 mm. ($5'8^7/_8''$).

As will be seen from fig. 285, the silent-blocks are similar to those of fig. 27, but smaller. For the remainder,

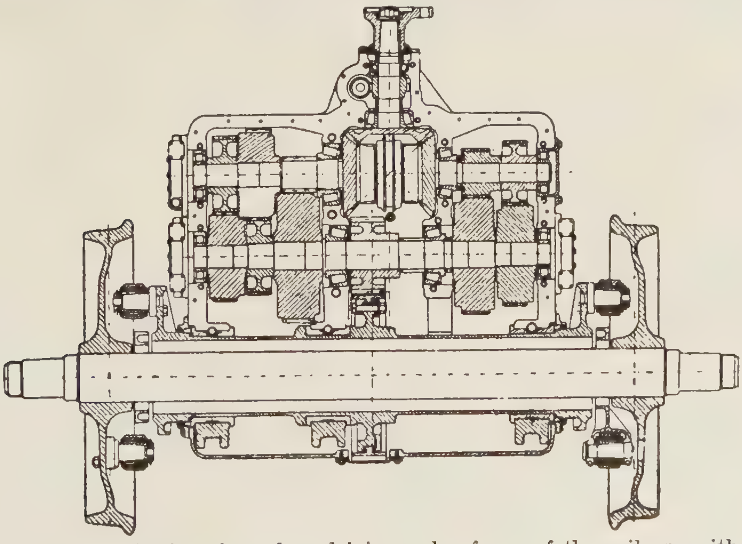
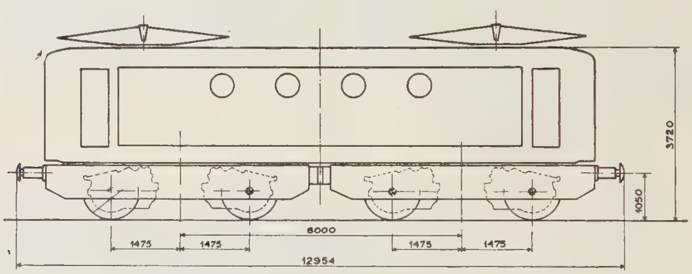


Fig. 291. — Section through a driving axle of one of the railcars with two internal combustion engines, No. XX D4006 of the SNCF. The same Als-Thom mechanism, with silent-blocks, as in figs. 285 and 286, can be seen on the hollow shaft, but the link with the hollow shaft is in the centre, in the longitudinal axis of the motor. Mounted on the hollow shaft, the transmission is 300 H.P. from the motor couple (gear box).

the mechanism is as described for the locomotives (see pp. 24-30).

Figs. 287 to 289 show, respectively, a dimensioned sketch, the bogie frame and the central bogie under the articulation of the coaches. Fig. 290 shows the traction motor forming one assembly with the hollow shaft.

3) Apart from these electric sets, and also in *France*, a combustion-motor-driven railcar of the SNCF has been fitted with this mechanism ([187]). This (see fig. 291) works perfectly well and requires much less maintenance than a transmission with a cardan shaft and motor saddle. However, the clutch linings in the gear case have to be changed every 80 000 km. (50 000 miles) approx., owing to the heavy duty performed by the car (running with trailer). The SNCF is hoping to remedy this by fitting a standard clutch between the motor and gear case to avoid using the clutch inside the gear case except as synchronisers



Als-Thom.

Fig. 292. — Dimensioned sketch of B_0-B_0 locomotives, series 1101, Nos. 1101-1125, of the Netherlands Railways, NS, under construction; fitted with the same silent-block mechanism as figs. 285 and 286. Axle load 20 tons, tare 80 tons, length of body 11 748 mm. (38′6[13]/[16]″), width of body 2 988 mm. (9′9[11]/[16]″).

is the series XXD car No. 4006, working in the Besançon district. It is a « De Dietrich » railcar of 500 H.P., which has two driving bogies on each of which is arranged a two-stroke engine with opposed pistons (CGM) and a transmission (L'Engrenage Co.).

The transmission, with hollow shaft and silent-blocks, mounted on the axle, with wheels of 860 mm. (2′9[7]/[8]″) dia. (first gear clutch to engage outside the gear case).

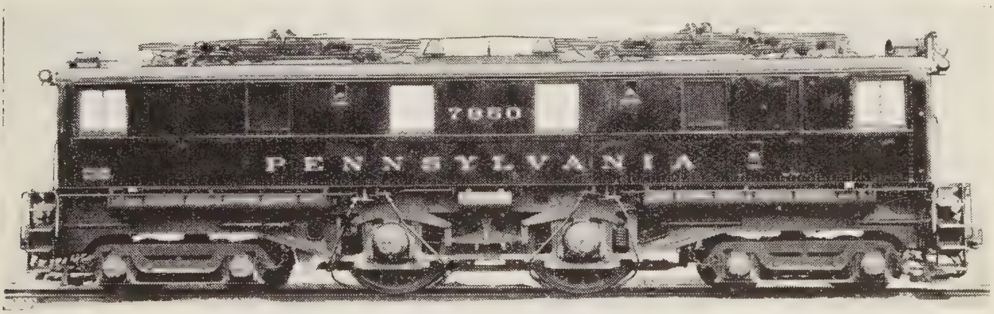
It would appear that there will be other applications of this nature, which it would seem will also make use of the axle drive with silent-blocks and that these are therefore perfectly satisfactory.

4) A C_0-C_0 locomotive, No. 6052, for single phase current, 20 kV., 50 cycles, ordered in 1948 from Als-Thom (see

([187]) See *Mécanique*, Paris, No. 326, June 1944, « Les automotrices à moteurs à combustion » (10 p., 13 figs. and table), Ch. TOURNEUR (see fig. 7, p. 143). — The combustion motor-driven railcars were previously designated ZZ, at present XX (SNCF). — See also *Revue Générale des Chemins de Fer*, Paris, March 1947, Ch. TOURNEUR, reproduced in the *Int. Railway Congress Bulletin*, Aug. 1948, pp. 492-505.

fig. 248 and relative text). Two pivot bogies, similar to those in fig. 283, but with symmetrical bases (2 350 mm. [7′8½″] between centres) are used.

5) Finally, we may mention the 25 B_0-B_0 locomotives ordered in the spring of 1948 from Als-Thom, Belfort, by the Netherlands Railways, NS (see fig. 292). These locomotives will be provided with mechanism similar to that of figs. 285 and 286.



Cliché SKF.

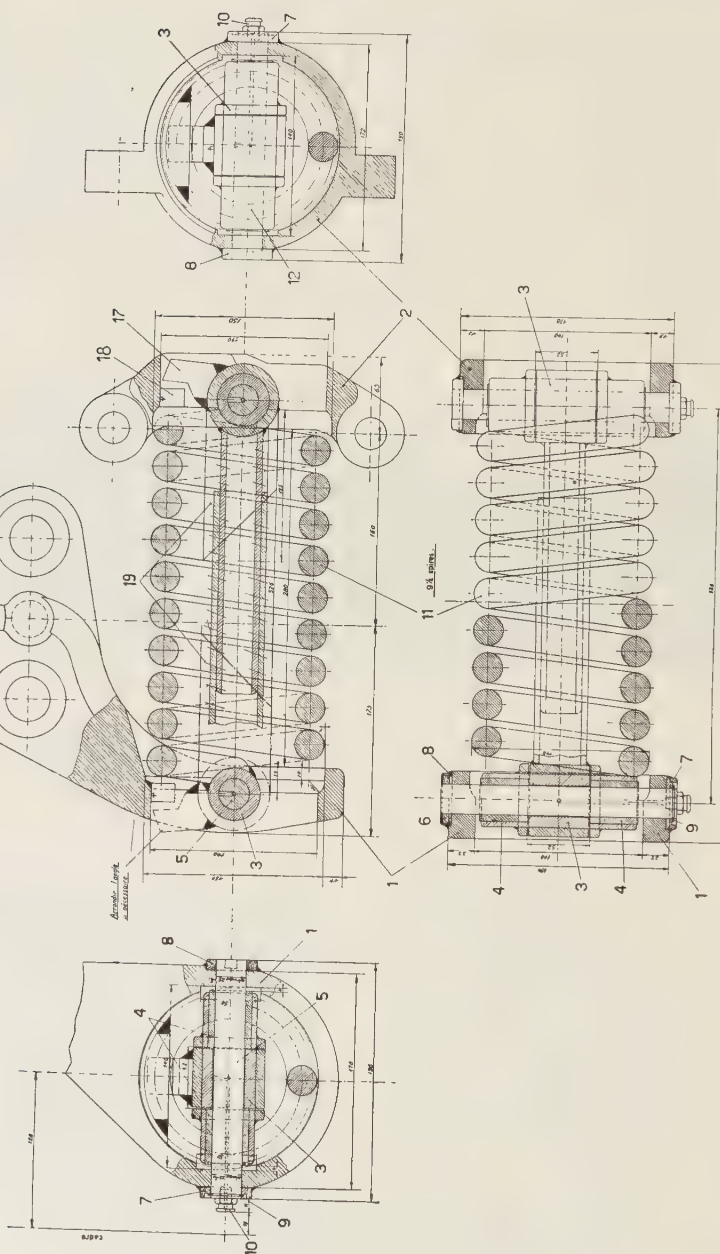
Fig. 293. — 01 class locomotive No. 7850 of the Pennsylvania RR (see fig. 16), which was fitted in 1944 with « Morch » push-rod mechanism, and later in the same year with rubber drive-mechanism as in fig. 117. This locomotive is provided with SKF roller bearing axleboxes. Drive and gears are unilateral.

Still within the framework of this Chapter III, on the subject of push rods, a record — for information only, since it no longer exists — may be made of an *American* mechanism which was fitted and worked for a number of years on an electric 2-B_0-2 locomotive, class 01, No. 7580, shown in fig. 293, of the Pennsylvania R.R. (PRR), already mentioned several times previously.

This was the « Morch » mechanism, developed by the PRR, somewhat similar on the one hand to the Ganz (Budapest) mechanism of 1902, used on the 3-phase locomotives Gr. E.334 of the Italian State Railways (Valteline line) and on the other hand to the Skoda (Pilsen) mechanism : these two arrangements were shown (and described) in figs. 10 and 121 respectively of **Cde. indiv.**

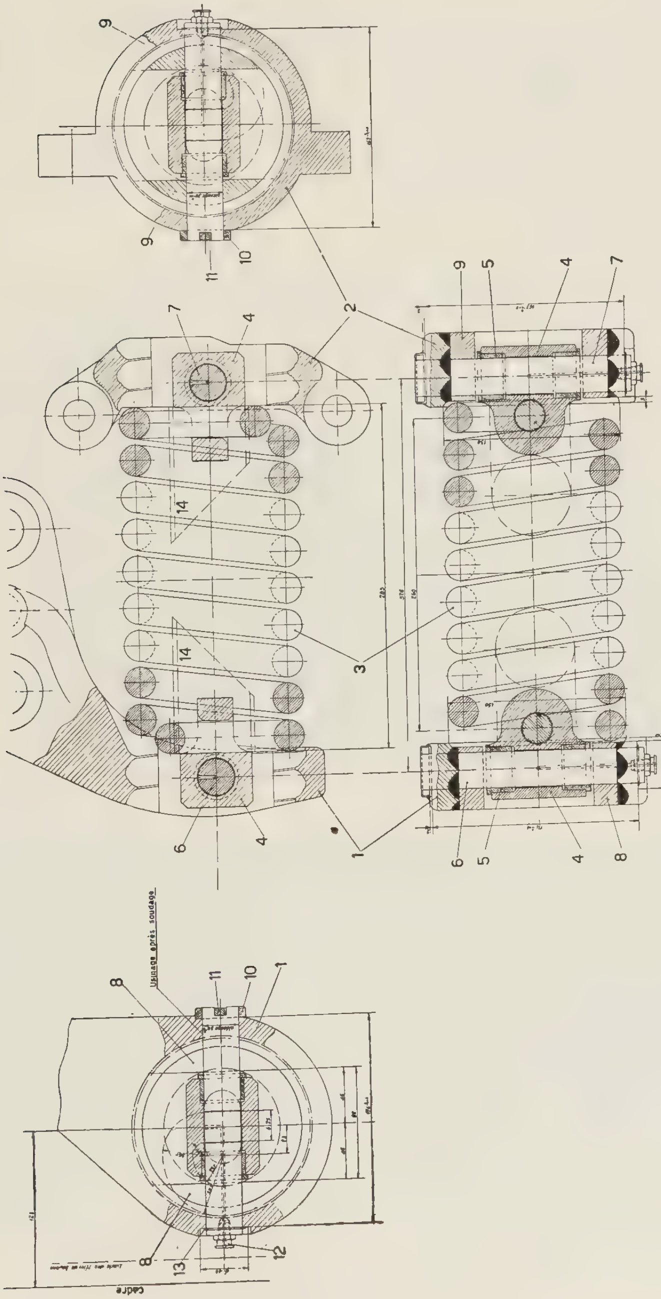
A sketch of this Morch mechanism will be given at the end of this article, since the mechanism is not known, and drawings only came to hand as this Supplement to Chapter III was going to press. The mechanism has been taken off and was definitely dispensed with in 1944; it was superseded on locomotive No. 7850 by the rubber cup drive of fig. 321.

As regards the push-rod and floating ring mechanism by Westinghouse (Pittsburgh, USA), 1927, of the New York, New Haven & Hartford RR (mentioned under F, under fig. 13, and in the right-hand column of the page following fig. 31), this is the mechanism in fig. 161 of **Cde. indiv.** (see also fig. 35 of this article).



Plan SBB - CFF.

Fig. 294. — 1946 trial arrangement, Yverdon Works of the Swiss Federal Railways SBB-CFF; improved seating of the Westinghouse mechanism springs on locomotives fitted with the mechanism. The seating of the ends of the springs is replaced by a pivoting arrangement designed to prevent the springs from curving.



Plan SBB - CFF.

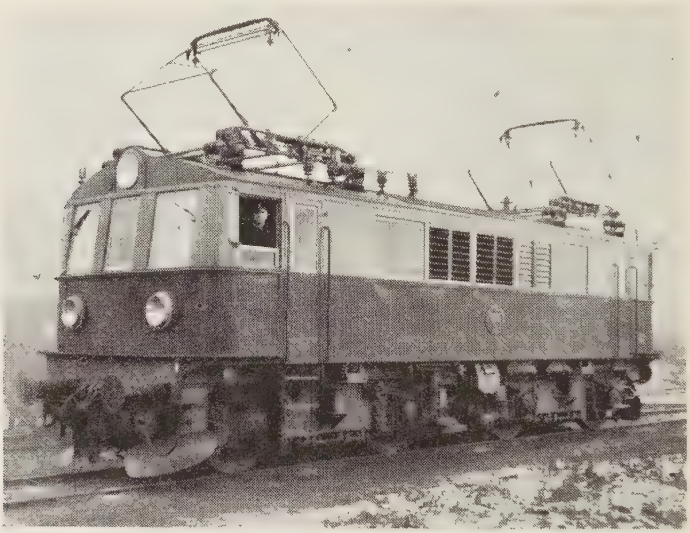
Fig. 295. — Trial arrangement similar to fig. 294, from the same works; improved, 1947 type.

General remarks on Chapter IV, Part 1

DRIVING MECHANISMS USING SPRINGS (OR RUBBER) WITH TRANSMISSION BY GEARS

With regard to 1 (under fig. 34, Chapter IV, PART 1), we have described, on the page with fig. 36, certain variations of the original Westinghouse « Quill drive ».

Further note may be taken of a *Swiss* variation. One of the Ae $^3/_6$ (2-C_0-1) locomotives of the 10266 and 10267 series of the Swiss Federal Railways SBB-CFF [188] still has two of its three [189] driving axles fitted with « quill drive » supplied by « Sécheron » of Geneva. The Yverdon Works of the CFF have introduced, for trial purposes, a modification designed to reduce the fatigue of springs in the region of their seating in the bearing plates; these bearing plates for the springs, instead of being fixed



Cliché SKF.

Fig. 296. — B_0-B_0 locomotive No. 215, Göteborg-Borås Railway (Sweden) with « Sécheron » I mechanism (twin springs). Power 2 500 H.P. hourly; tare 71 tons (*).

(188) Engines noted under categorie Ae $^3/_6$, 111, p. 37, right column of **Cde. indiv.**, similar (apart from carrying axles) to those in figs. 76-78 of **Cde. indiv.**

(189) The third axle was fitted experimentally with the « Meyfarth-Sécheron » mechanism. One axle of locomotive 10267, same series, was fitted with the first Brown Boveri disc mechanism, shown in Chap. VI, figs. 240-243 : the locomotive shown was described (pp. with figs. 239-241) as No. 10264 of the same series : such trial axles can frequently be changed from one locomotive to another, and this illustrated rather the type of the mechanism than the locomotive.

(*) The text by the right of the fig. 57 quoted fig. 63 for these locomotives, in error.

rigidly to the arms of the wheels and hollow shafts, are articulated on studs around which the plates can oscillate (see figs. 294 and 295).

It is not yet possible to say anything about the behaviour of these 1946 and 1947 innovations and results of their service will not become available for some years. Stress must be laid on the fact, as stated by the CFF, that these are *trials* and they must not yet be considered as adopted.

Photo Ad.-M. Hug.

Fig. 297. — B_0-B_0 locomotive No. 552, « Hd » class, shunting a goods train (this series, apart from 552 converted, is fitted with « Sécheron » I mechanism, as fig. 296).

The life of an original Westinghouse quill drive spring, with the former method of seating the springs (figs. 34 and 36) is about 130 000 km. (81 000 miles).

— With regard to 3 — « Sécheron » I mechanism :

We have noted that the Ae $^6/_8$ locomotive, 1-C_0+C_0-1 type, No. 207 of the Swiss BLS, shown in fig. 44 was fitted with « Meyfarth-Sécheron » mechanism. A further illustration, showing this in service, will be given later.

— On the subject of the *Russian* diesel-electric type 1-E_0-1 (2-E_0-1 respectively), briefly described on the page containing fig. 46 [see figs. 47 and 50

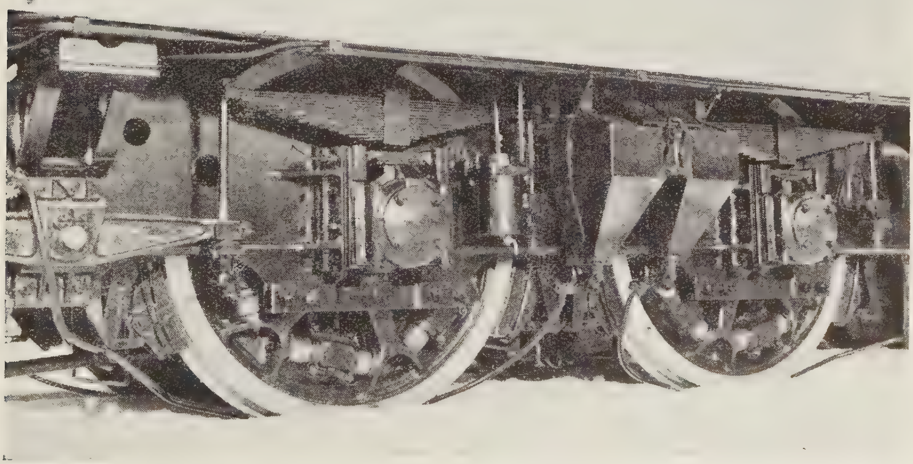


Photo ASEA (Motala).

Fig. 298. — Part-set of wheels, Swedish SJ express electric locomotives, « F » class, type 1-D_0-1, series 621, 3 000 H.P. (see figs. 91 and 92). (SKF roller-bearing boxes.)

and note ([41])] the list of references is completed ([190]).

On the page with figs. 56 and 57, concerning *Sweden,* mention was made of 10 B_0-B_0 locomotives of the GBJ (Göteborg-Borås) railway, fitted with « Sécheron » I mechanism. These locomotives have a full-length body, without projections or bonnets at either end (see fig. 296). This railway has recently been incorporated as a part of the Swedish State Railways, SJ. The SJ already had 4 B_0-B_0 locomotives (as shown above fig. 59) but with a central cabin and bonnets at each end. These engines (see fig. 297) have, on the SJ, been classified « Hd » and are numbered 551 tot 554.

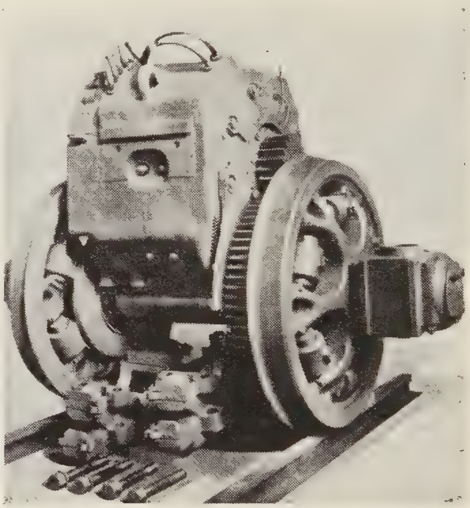
The springs of the flexible transmission have given some trouble and have had a limited life, particularly in view of the fact that the SJ habitually use locomotives up to their limit of adhesion, which naturally increases the cost of maintenance.

However, locomotive No. 552 (fig. 297) was converted in 1946 and the « Sécheron » mechanism was replaced by the new rubber disc arrangement by the ASEA Co. This will be dealt with later under the applications of mechanisms using rubber (Part 2 of Chapter IV).

We may also note that numerous applications on locomotives of private railways in *Switzerland,* also on the Lötschberg BLS (see figs. 37-43 and 45) are giving satisfactory results in service.

With regard to 4), *quill cup drive* (or Kleinow-AEG) :

— It is stated under *Sweden*-SJ, on the page with figs. 90-97, that 22, F class, locomotives, type 1-D_0-1, for fast trains, Nos. 601 and 621-642, were fitted with Kleinow-AEG mechanism. The Swedish SJ, however, considers that whilst the mechanism as a whole is suitable, the wear on couples and bearing plates is too heavy and that lubrication is too complicated and difficult.



Cliché SKF.

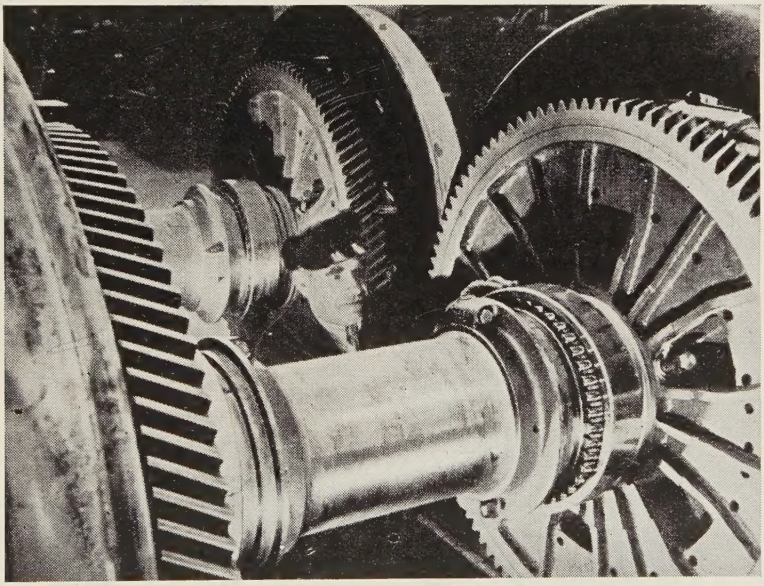
Fig. 299. — Driving axle complete with motor and unilateral gear (right teeth) and quill-cup mechanism, similar to that of the locomotives in figs. 91, 92 and 298, but of smaller diameter (compare with Reichsbahn DR type, fig. 83).

Consequently, « F » class locomotives Nos. 601 and 642 of this series have been converted and the Kleinow-AEG (quill cup drive) mechanism replaced for trial purposes by rubber blocks of the Pennsylvania R.R. type (see fig. 117). We shall return to this matter when dealing

([190]) See publication by I. FRANCO † and P. LABRIJN, Publishers Martinus Nijhoff, The Hague, 1931. « Locomotives and railcars with internal combustion engines » [English (1931), French (1932) and German (1931/32) editions].

with this particular mechanism (uses of rubber).

In order to illustrate more clearly the arrangement around the axles of the AEG couples, we are including fig. 298 which shows a part of the set of wheels under one of these locomotives (for comparison with figs. 91 and 92). A general arrangement drawing of the mechanism is not reproduced, in view of its close similarity to fig. 111; it may, however, be noted that the main gear wheel is keyed to the hollow shaft by screws set almost vertically (at about 15° from the vertical, with the head upwards) and that the gearcase is mounted on the roller bearing (exterior spherical surface of the rollers). In addition, the section at the joint of the two half-couples is not vertical as in fig. 111 but is set at 20° from the vertical, at an angle almost leading inside the track; the maximum release of the couples from the vertical central standing position is 26 mm. ($1^1/_{32}''$) vertically and 31 mm. ($1^7/_{32}''$) obliquely (towards the wheel tyre). The number of spring couples on Swedish « F » class locomotives is 6, the diameter of the driving wheels 1 530 mm. ($5'\frac{1}{4}''$) (fig. 91) and the ratio of the transmission gears 23 : 76. The maximum amount of vertical play of the axleboxes is 30 mm. ($1^3/_{16}''$).

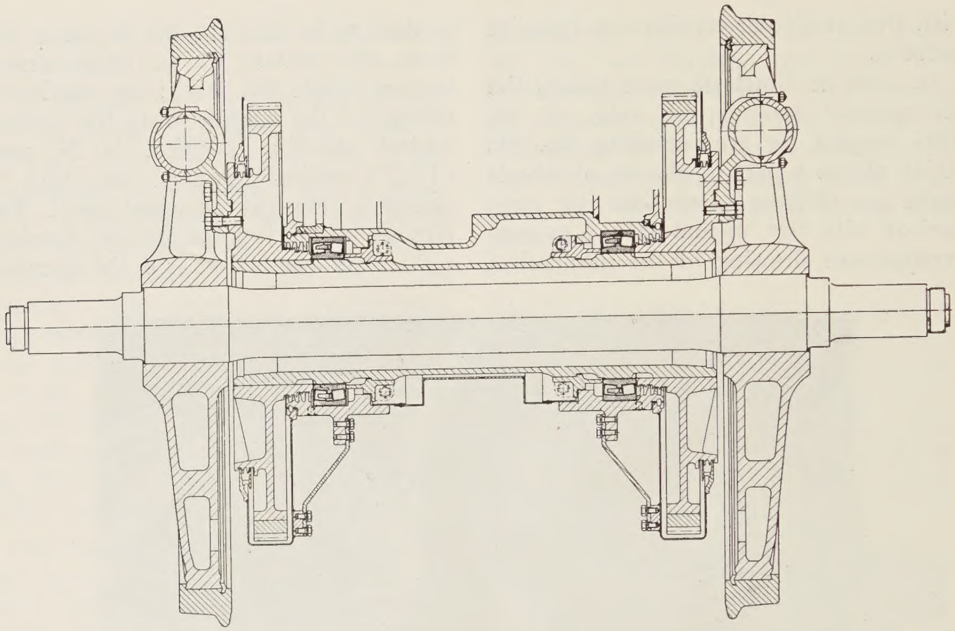


Cliché SKF.

Fig. 300. — Gear wheels (oblique teeth, bilateral gears) mounted on the hollow shaft and roller bearings for the motor body. Variant of figs. 82, 298 and 299. « Quill cup » drive.

Figs. 299 to 301 show these modifications; the axleboxes are SKF rollers.

Another use of the SKF couples, is that on locomotives of the Norwegian State (NSB) Railways, type $1\text{-}D_0\text{-}1$



Cliché SKF.

Fig. 301. — Section through centre line of driving axle in fig. 300.

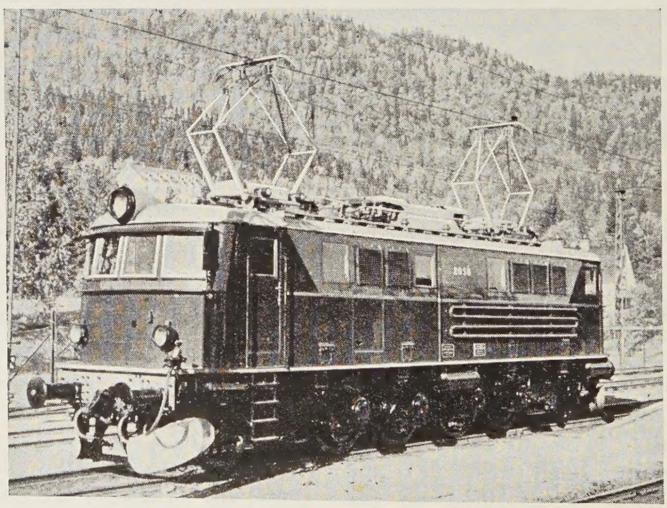
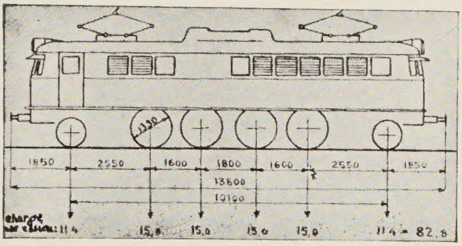


Photo NSB.

Fig. 302. — 1-D_0-1 class electric locomotive, class El.8, No. 2058, Norwegian NSB (2 800 H.P. at 70 km./h. [43 m.p.h.] max. speed 110 km./h. [68 m.p.h.], tare 83 tons. Isothermos boxes.)

($1'D_01'$), El.8 class. These are 16 locomotives, Nos. 2054-2061, put into service in 1940/1941, and Nos. 2065-2067, in 1945, and No. 1068 in 1948 : for others are at present under construction ([191]).

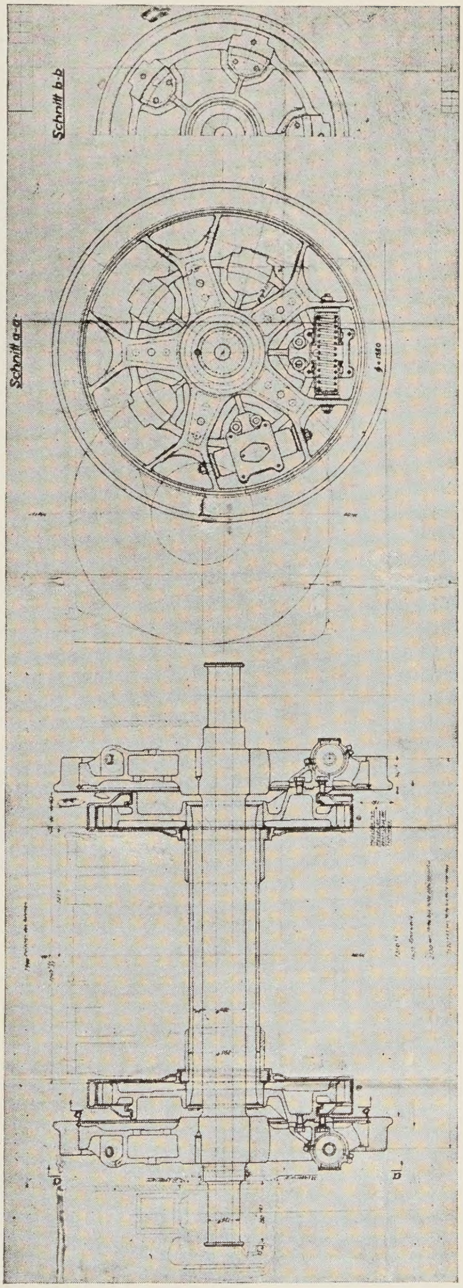
Figs. 302 and 303, respectively, show locomotive No. 2058 standing, and a dimensioned sketch of the El.8 class. The NSB, like the Swedish railways, intend to replace the Kleinow-AEG, by the rubber drive shown in fig. 117, Pennsylvania type, if the trials at present being conducted on locomotive No. 2054 give satisfactory results, up to the present they are completely successful. All these locomotives have bilateral gears and drive ([191]).



NSB.

Fig. 303. — Dimensioned sketch of locomotive in fig. 302.

Like the Swedish, class F, locomotives (see text below fig. 39), these Norwegian locomotives have simple Bissels for the carrying axles. It may also be recalled that the Norwegian Railways, like those in Sweden, Switzerland, Germany and Austria, use single-phase current of 15 kV., 16 $^2/_3$ cycles.



Plan AEG (NSB).

Fig. 304. — Driving axle, in elevation and section, of locomotives in figs. 302 and 303 (see fig. 77). The cup-drive mechanism has five elements, the motor being arranged to the side of the axle. Driving wheel diameter — 1 350 mm. (4'5 $^3/_8$"). The linking of the driving and gear wheels can be seen. (Schnitt = Section.)

(191) The 3 locomotives 2062-2064, El.9 class, acquired in 1947, have nose-suspended motion and unilateral gears. They are intended for heavily-graded lines (Flåmsbanen) with gradients up to 55 per mille.

(To be continued.)